JC20 Rec'd PCT/PTO 27 MAR 2002

FORM PTO-1390 (REV. 5-93)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER NIT-336
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)		U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/089170
International Application No. PCT/JP99/05401	International Filing Date March 15, 2000	Priority Date Claimed
Title of Invention ELECTRON SOURCE, METHOD OF MANUFACTURE THEREOF, AND DISPLAY DEVICE		
Applicant(s) for DO/EO/US M. SAGAWA et al (see attached)		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information:

[X] LIST OF INVENTORS' NAMES AND ADDRESSES.

10089170

JC13 Rec'd PCT/PTC 27 MAR 2002

U.S. Application No. (if known, see 37 CFR 1.5)	International Application No.	Attorney's Docket Number
10/089170	PCT/JP99/05401	NIT-336

17. [X] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492 (a)(1)-(5)): Search Report has been prepared by the EPO or JPO .... $890.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) .... $710.00 No international preliminary examination fee (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445 (A)(2)) .... $740.00 Neither international examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(A)(2)) paid to USPTO .... $1040.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). +	$ 0.00	

Claims	Number Filed	Number Extra	Rate		
Total	32 -20 =	12	x $18.00	$ 216.00	
Independent	10 - 3 =	7	x $84.00	$ 588.00	
Multiple dependent claim(s) (if applicable)			+ $280.00	$ 0.00	
TOTAL OF ABOVE CALCULATIONS =				$ 1,694.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ 0.00	
SUBTOTAL =				$ 1,694.00	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0.00	
TOTAL NATIONAL FEE =				$ 1,694.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property. +				$ 0.00	
TOTAL FEES ENCLOSED =				$ 1,694.00	
				Amount to be: Refunded	$
				Charged	$

a. [X] **A check in the amount of $ 1,694.00 to cover the above fees is enclosed.**

b. [ ] **Please charge my Deposit Account No. 50-1417 in the amount of $ ________ to cover the above fees. A duplicate copy of this sheet is enclosed.**

c. [X] **The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1417. A duplicate copy of this sheet is enclosed.**

Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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24956
PATENT TRADEMARK OFFICE

John R. Mattingly
Signature

John R. Mattingly
Name

30,293
Registration Number

NIT-336

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

M. SAGAWA et al

Serial No.

Filed: March 27, 2002

For: ELECTRON SOURCE, METHOD OF MANUFACTURE THEREOF, AND DISPLAY DEVICE

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination thereof, please amend the above-identified application as follows.

IN THE CLAIMS

Rewrite claims 1-4, 6, 7, 9, 12, 13, 16-21, 23-30 and 32 as follows:

1. (Amended) An electron source comprising:

a plurality of electron source elements; and

a plurality of bus electrodes that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a

film thickness thicker than that of the thin film electrode plating.

2. (Amended) An electron source according to claim 1, wherein the thin film electrode comprises a tungsten film.

3. (Amended) A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness

thicker than that of the thin film electrode, and said thick film electrode being formed by plating.

4. (Amended) A thin film type electron emitter according to claim 3, wherein the thin film electrode has a film thickness that is less than or equal to ten times as thick as a film thickness of the top electrode, and that is less than or equal to 20 nm.

6. (Amended) A thin film type electron emitter according to claim 3, wherein the thin film electrode comprises a tungsten film.

7. (Amended) A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a

first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode, and said thick film electrode being formed by plating.

9. (Amended) A thin film type electron emitter according to claim 7, wherein the thin film electrode comprises a tungsten film.

12. (Amended) A method of manufacturing a thin film type electron emitter according to claim 10, wherein in the step 5 of selectively patterning the thick conductive film, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 6 of selectively patterning the thin conductive film, an open area where the insulating layer is

exposed is formed in the thin film electrode inside the open area which is formed in the thick film electrode; and

in the step 7 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode that is exposed in the open area provided on the thick film electrode.

13. (Amended) A method for manufacturing a thin film type electron emitter according to claim 10, wherein in the step 4 of forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

16. (Amended) A method of manufacturing a thin film type electron emitter according to claim 14, wherein in the step 4 of selectively forming the thick film electrode, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 5 of selectively patterning the thin conductive film, an open area where the insulating layer is exposed is formed in the thin film electrode; and

in the step 6 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode that is exposed in the open area provided on the thick film electrode.

17. (Amended) A method of manufacturing a thin film type electron emitter according to claim 14, wherein in the step 4 of selectively forming the thick film electrode, the thick film electrode is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

18. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements; and

a plurality of bus electrodes that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having a phosphor;

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the electrode of the electron source element, and that is less than or equal to 20 nm; and;

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

19. (Amended) A display device according to claim 18, wherein the thin film electrode has a film thickness that is less than or equal to 10 nm.

20. (Amended) A display device according to claim 18, wherein the thin film electrode has a film thickness ranging from 1 to 9 nm.

21. (Amended) A method of manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a

bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode integrated with the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of selectively forming a thick film electrode on the thin conductive film by plating or printing; and

a step 5 of forming the thin film electrode and the top electrode by selectively patterning the thin conductive film.

23. (Amended) A method of manufacturing a thin film type electron emitter according to claim 21, wherein the thin film electrode comprises a tungsten film.

24. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements; and

a plurality of bus electrodes that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the electrode of the electron source element, and that is less than or equal to 20 nm; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode being thicker than the thin film electrode, and said thick film electrode being formed by plating.

25. (Amended) A display device according to claim 24, wherein the thin film electrode comprises a tungsten film.

26. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to the top electrode, said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the top electrode, and that is less than or equal to 20 nm; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode, and said thick film electrode being formed by a plating.

27. (Amended) A display device according to claim 26, wherein the thin film electrode has a film thickness ranging from 1 to 9 nm.

28. (Amended) A display device according to claim 26, wherein each of the thin film electrode and the thick film electrode has an open area where the insulating layer is exposed;

the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode; and

the top electrode is provided so as to cover the thin film electrode that is exposed in the open area provided in the thick film electrode.

29. (Amended) A display device according to claim 26, wherein the thin film electrode comprises a tungsten film.

30. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor;

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode being thicker than the thin film electrode, and said thick film electrode being formed by plating or printing.

32. (Amended) A display device according to claim 30, wherein the thick film electrode is formed by plating.

IN THE ABSTRACT

Pages 51 and 52, "ABSTRACT" section, delete this section in its entirety and replace with:

ABSTRACT

A thin film type electron emitter has a plurality of electron source elements, each of which has a structure in which a bottom electrode (11), an insulating layer (12), and a

top electrode (13) are laminated in this order, and each of which emits electron from the surface of the top electrode when applying a positive voltage to the top electrode; and a plurality of the bus electrodes that apply the driving voltage to the top electrode of the electron source element in the first direction among the plurality of electron source elements. Each of the bus electrodes comprises a thin film electrode (15) electrically connected to the top electrode; and a thick film electrode (16) that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode.

REMARKS

Examination is requested.

Respectfully submitted,

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Date: March 27, 2002

MARKED UP VERSION OF REWRITTEN CLAIMS

1. (Amended) An electron source comprising:

a plurality of electron source elements; and

a plurality of bus electrodes that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements[, said thin film electrode having a film thickness that is less than or equal to a film thickness of the electrode of the electron source element]; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode plating.

2. (Amended) An electron source according to claim 1, wherein the thin film electrode comprises a tungsten film [thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing].

3. (Amended) A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode<u>, and said thick film electrode being formed by plating</u>.

4. (Amended) A thin film type electron emitter according to claim 3, wherein the thin film electrode has a

film thickness that is less than or equal to ten times as thick as a film thickness of the top electrode, and that is less than or equal to 20 nm.

6. (Amended) A thin film type electron emitter according to [any of] claim[s] 3 [to 5], wherein the [thick] thin film electrode [is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen printing] comprises a tungsten film.

7. (Amended) A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode, and said thick film electrode being formed by plating.

9. (Amended) A thin film type electron emitter according to claim 7 [or 8], wherein the [thick] thin film electrode [is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing] comprises a tungsten film.

12. (Amended) A method of manufacturing a thin film type electron emitter according to claim 10 [or 11], wherein in the step 5 of selectively patterning the thick conductive film, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 6 of selectively patterning the thin conductive film, an open area where the insulating layer is

exposed is formed in the thin film electrode inside the open area which is formed in the thick film electrode; and

in the step 7 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode that is exposed in the open area provided on the thick film electrode.

13. (Amended) A method for manufacturing a thin film type electron emitter according to [any of] claim[s] 10 [to 12], wherein in the step 4 of forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

16. (Amended) A method of manufacturing a thin film type electron emitter according to claim 14 [or 15], wherein in the step 4 of selectively forming the thick film electrode, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 5 of selectively patterning the thin conductive film, an open area where the insulating layer is exposed is formed in the thin film electrode; and

in the step 6 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode that is exposed in the open area provided on the thick film electrode.

17. (Amended) A method of manufacturing a thin film type electron emitter according to [any of] claim[s] 14 [to 16], wherein in the step 4 of selectively forming the thick film electrode, the thick film electrode is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

18. (Amended) A [method of manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode integrated with the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality

of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of forming a thick conductive film on the thin conductive film;

a step 5 of forming the thick film electrode by selectively patterning the thick conductive film; and

a step 6 of forming the thin film electrode and the top electrode by selectively patterning the thin conductive film] display device comprising:

a first substrate including:

a plurality of electron source elements; and

a plurality of bus electrodes that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having a phosphor;

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the electrode of the electron source element, and that is less than or equal to 20 nm; and;

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

19. (Amended) A [method for manufacturing a thin film type electron emitter according to claim 18, wherein in the step 5 of selectively patterning the thick conductive film, an open area where the insulating layer is exposed is formed in the thick film electrode] display device according to claim 18, wherein the thin film electrode has a film thickness that is less than or equal to 10 nm.

20. (Amended) A [method of manufacturing a thin film type electron emitter according to claim 18 [or 19], wherein in the step 4 of forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen-printing] display device according to claim 18 or 19, wherein the thin film electrode has a film thickness ranging from 1 to 9 nm.

21. (Amended) A method of manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode integrated with the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of selectively forming a thick film electrode on the thin conductive film by plating or printing; and

a step 5 of forming the thin film electrode and the top electrode by selectively patterning the thin conductive film.

23. (Amended) A method of manufacturing a thin film type electron emitter according to claim 21 [or 22], wherein [in the step 4 of selectively forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing] the thin film electrode comprises a tungsten film.

24. (Amended) A display device comprising:

a first substrate including: [comprising]

a plurality of electron source elements[,]; and

a plurality of bus electrodes [applying] that apply a driving voltage to an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the electrode of the electron source element, and that is less than or equal to 20 nm [is less than or equal to a film thickness of the electrode of the electron source element]; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode [having a film thickness thicker than that of the thin film electrode] being thicker than the thin film electrode, and said thick film electrode being formed by plating.

25. (Amended) A display device according to claim 24, wherein [the thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing] the thin film electrode comprises a tungsten film.

26. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to the top electrode[; and], said thin film electrode having a film thickness that ranges from one tenth to ten times as thick as a film thickness of the top electrode, and that is less than or equal to 20 nm; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode, and said thick film electrode being formed by a plating.

27. (Amended) A display device according to claim 26, wherein the thin film electrode has a film thickness [that is less than or equal to ten times as thick as a film thickness of the top electrode] ranging from 1 to 9 nm.

28. (Amended) A display device according to claim 26 [or 27], wherein each of the thin film electrode and the thick

film electrode has an open area where the insulating layer is exposed;

the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode; and

the top electrode is provided so as to cover the thin film electrode that is exposed in the open area provided in the thick film electrode.

29. (Amended) A display device according to any of claims 26 [to 28, wherein the [thick] <u>thin</u> film electrode [is a metallic layer that is formed by any of one of plating, vacuum evaporation, chemical vapor deposition, and screen-printing] <u>comprises a tungsten film</u>.

30. (Amended) A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor;

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode [having a film thickness thicker than that of the thin film electrode] being thicker than the thin film electrode, and said thick film electrode being formed by plating or printing.

32. (Amended) A display device according to claim 30 [or 31], wherein the thick film electrode is [a metallic layer

that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing] formed by plating.

MARKED UP VERSION OF REPLACED SECTION(S) OF THE SPECIFICATION

Pages 51 and 52, "ABSTRACT" section, the marked up version of this section is:

ABSTRACT

A thin film type electron emitter [comprises] has a plurality of electron source elements, each of which has a structure in which a bottom electrode (11), an insulating layer (12), and a top electrode (13) are laminated in this order, and each of which emits electron from the surface of the top electrode when applying a positive voltage to the top electrode; and a plurality of the bus electrodes that apply the driving voltage to the top electrode of the electron source element in the first direction among the plurality of electron source elements. Each of the bus electrodes comprises a thin film electrode (15) electrically connected to the top electrode; and a thick film electrode (16) that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode.

[Additionally, the thin film electrode has a film thickness that is almost the same as that of the top electrode. Moreover, each of the thin film electrode and the thick film electrode has an open area where the insulating

layer is exposed. In addition to it, the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode. The top electrode is provided so as to cover the thin film electrode that is exposed in the open area provided in the thick film electrode.

This prevents an increase in resistance of the bus electrode for power supply that applies the driving voltage to the electron source element, and also prevents the top electrode from being broken along the edge of the thin film electrode in the electron-emitting portion.]

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DESCRIPTION

ELECTRON SOURCE, METHOD OF MANUFACTURE THEREOF, AND DISPLAY DEVICE

TECHNICAL FIELD

The present invention relates to an electron source, a method of manufacturing the electron source, and a display device, and more particularly to a technology which is effective in being applied to a thin film type electron emitter that has a three-layer structure made of a bottom electrode, an insulating layer, and a top electrode, and that emits electrons into a vacuum.

BACKGROUND ART

As one of matrix display devices (matrix display), in which an intersection point of electrode groups orthogonal to each other serves as a pixel, and which displays an image by adjusting voltage applied to each pixel, a field emission display (hereinafter referred to as FED) is known.

As described in Japanese Patent Laid-open No. Hei 4-289644 for example, this FED is devised as follows: an electron emitter is placed at each pixel; and after accelerating electrons, which are output from the electron

emitter, in a vacuum, the FED irradiates a phosphor with the electron so that the phosphor in the irradiated part emits light.

As an example of an electron emitter used for FED, a thin film type electron emitter matrix is known.

The thin film type electron emitter is so devised that voltage is applied, for example, between a top electrode and a bottom electrode of a three-layer structure made of the top electrode, an insulating layer, and the bottom electrode in order to emit an electron from a surface of the top electrode into a vacuum.

For example, the following are known: the MIM (Metal - Insulator - Metal) type in which a metal, an insulator, and a metal are laminated; the MIS (Metal - Insulator - Semiconductor) type in which a metal, an insulator, and a semiconductor electrode are laminated; the type in which a metal, a laminated film of an insulator and a semiconductor, and a metal or a semiconductor electrode are laminated; and the like.

Incidentally, the MIM type thin film electron source is described in Japanese Patent Laid-open No. Hei 7-65710 for example.

Fig. 24 is a diagram illustrating the principles of operation of the thin film type electron emitter.

Applying a driving voltage of Vd output from a

driver circuit between a top electrode 13 and a bottom electrode 11 to create an electric field approximately ranging from 1 to 10 MV/cm in a tunnel insulating layer 12 causes electrons in proximity to a Fermi level in the bottom electrode 11 to transmit a barrier by a tunnel phenomenon. Then, the electrons enter into a conduction band of the tunnel insulating layer 12 and the top electrode 13 to become hot electrons.

Among these hot electrons, those having energy of a work function (ϕ) of the top electrode 13 or more are emitted into a vacuum 20.

In this case, providing the plurality of top electrodes 13 and the plurality of bottom electrodes 11, and forming thin film type electron emitters in a matrix form so that the plurality of top electrodes are orthogonal to the plurality of bottom electrodes 11, permits an electron beam to be generated at an arbitrary position. This enables us to employ the thin film type electron emitter as an electron source of a display device.

In the past, electron emission is observed in the MIM (Metal - Insulator - Metal) structure made of gold (Au), aluminum oxide (Al_2O_3: hereinafter merely referred to as Al_2O_3), and aluminum (Al: hereinafter merely referred to as Al), and in others.

The MIM thin film type electron emitter transmits

hot electrons, which is accelerated in the tunnel-insulating layer 12, through the top electrode 13 to emit the hot electron into a vacuum.

Therefore, the film thickness of the top electrode 13 is required to be very thin (about several nm) in order to suppress scattering of hot electrons.

Accordingly, sheet resistance of the top electrode 13 becomes about 200 Ω/□. As a result, wiring resistance per unit length reaches 7 kΩ/cm.

In this case, because operating voltage of the thin film type electron emitter element is 10 V and consumed electric current is 1 mA, a voltage drop caused by wiring resistance becomes 7 V/cm.

Such a large voltage drop is completely fatal when trying to upsize the display screen of the display device in which the thin film type electron emitter is employed. For this reason, measures against the voltage drop become absolutely necessary.

Although the voltage drop can be compensated by a driving method, it is not desirable because a drive circuit becomes complicated, and because of the poor reliability of the very thin film wiring.

Essentially, providing additional wiring for power supply is indispensable.

In addition, the wiring for power supply should

satisfy four points as follows: (1) Resistance of the wiring for power supply is low; (2) Electrical contact between the top electrode 13 and a feeder line is provided; (3) The top electrode 13 is not broken at the sharp pattern edge ; and (4) Formation of the wiring for power supply does not exert an influence on the thin film type electron emitter element of the tunneling diode structure.

As a wiring material for power supply like this, Al alloy can be considered.

For example, Al - neodymium (Nd: hereinafter merely referred to as Nd) (2 atm%) alloy, which is also adopted as the bottom electrode 11, is a low resistance material having an outstanding heat-resistance property. However, this material has difficulties in the items (2) and (3). To be more specific, because natural oxide always exists on the surface of Al, the problem of contact resistance arises.

In addition, controllability of taper processing using wet etching or reactive ion etching (RIE) is not enough to prevent breakage at the pattern edge. Accordingly, damage to the tunneling insulator 12 used as a stopper cannot also be ignored.

In view of the foregoing, the present invention has been made, and the object of the present invention is to provide an technology that can decrease resistance of the bus electrode for power supply, and that can prevent the

electrode of the electron source in the electron emitting portion from being broken at the edge of the bus electrode, in the electron source, and a method for manufacturing the electron source.

Moreover, another object of the present invention is to provide a technology that can prevent uneven brightness on the display screen by using the thin film type electron emitter in the display device.

The above-mentioned and other objects of the present invention, and new features thereof, will be made clear by a description in this specification and with reference to attached drawings.

DISCLOSURE OF INVENTION

Outlines of typical features of the present invention disclosed in this application concerned will be briefly described below.

The present invention relates to the electron source comprising: the plurality of electron source elements; and

the plurality of bus electrodes that apply driving voltage to the electron source element in the first direction among the plurality of electron source elements, wherein each of the bus electrodes comprises: a thin film electrode electrically connected to the electrode of each of the electron source elements, said thin film electrode

having a film thickness that is less than or equal to ten times as thick as a film thickness of the electrode of the electron source element; and a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

In addition, the present invention relates to the thin film type electron emitter comprising: the plurality of electron source elements, each of which has a structure in which the bottom electrode, the insulating layer, and the top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and the plurality of bus electrodes that apply driving voltage to the top electrode of an electron source element in the first direction among the plurality of electron source elements, wherein each of the bus electrodes comprises: a thin film electrode electrically connected to the top electrode; and a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

Moreover, the present invention relates to the thin film type electron emitter comprising: the plurality of electron source elements, each of which has a structure in which the bottom electrode, the insulating layer, and the

top electrode are laminated in this order, and each of which emits electrons from the surface of the top electrode when applying positive voltage to the top electrode; and the plurality of bus electrodes that apply driving voltage to the top electrode of the electron source element in the first direction among the plurality of electron source elements, wherein each of the bus electrodes comprises: a thin film electrode that is integrated with the top electrode; and a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

Further, the present invention is characterized in that the thick film electrode is formed by any of electroplating, sputtering, vacuum evaporation, chemical vapor deposition, and screen-printing.

Furthermore, the present invention relates to a display device that employs the thin film type electron emitter.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a diagram illustrating a structure of the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 2 is a diagram illustrating a method for manufacturing the thin film type electron emitter according

to the first embodiment of the present invention;

Fig. 3 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 4 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 5 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 6 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 7 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 8 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the first embodiment of the present invention;

Fig. 9 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the second embodiment of the present invention;

Fig. 10 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the second embodiment of the present invention;

Fig. 11 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the second embodiment of the present invention;

Fig. 12 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to a third embodiment of the present invention;

Fig. 13 is a diagram illustrating a method for manufacturing a thin film type electron emitter according to the third embodiment of the present invention;

Fig. 14 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the third embodiment of the present invention;

Fig. 15 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the fourth embodiment of the present invention;

Fig. 16 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the fourth embodiment of the present invention;

Fig. 17 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the fourth embodiment of the present invention;

Fig. 18 is a diagram illustrating a method for manufacturing the thin film type electron emitter according to the fourth embodiment of the present invention;

Fig. 19 is a schematic diagram illustrating a

configuration of the thin film type electron emitter array substrate of the display device according to the fifth embodiment of the present invention;

Fig. 20 is a schematic diagram illustrating a configuration of the phosphor plate of the display device according to the fifth embodiment of the present invention;

Fig. 21 is a cross section schematically illustrating a whole configuration of the display device according to the fifth embodiment of the present invention;

Fig. 22 is a schematic diagram illustrating a state in which drive circuits are connected to the display device according to the fifth embodiment of the present invention;

Fig. 23 is a timing chart illustrating an example of the waveform of driving voltage which is output by each of the driving circuits shown in Fig. 22; and

Fig. 24 is a diagram illustrating the principles of operation of the thin film type electron emitter.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

It is to be noted that in all of the drawings for illustrating the embodiments, each component having the same function is designated by the similar reference numeral and the duplicated description thereof will be

omitted.

[First Embodiment]

Fig. 1 is a cross section illustrating a structure of one element of the thin film type electron emitter according to the first embodiment of the present invention.

The thin film type electron emitter according to this embodiment is characterized in that the bus electrode, which is used as a feeder line, comprises the bus electrode lower layer 15 electrically connected to the top electrode 13, and the bus electrode upper layer 16 that backs the bus electrode lower layer 15, the bus electrode upper layer 16 being formed by ~~a~~ sputtering.

A method for manufacturing the thin film type electron emitter according to this embodiment will be described below with reference to Figs. 2 to 8.

Incidentally, Figs. 2(a) to 8(a) each are a plan view; Figs. 2(b) to 8(b) each are a cross section that illustrates a cross-sectional structure along the cutting plane line A-A' of each of Figs. 2(a) to 8(a); and Figs. 2(c) to 8(c) each are a cross section that illustrates a cross-sectional structure along the cutting plane line B-B' of each of Figs. 2(a) to 8(a).

To begin with, an insulative substrate 10 such as glass is prepared, and then a metal film used for the bottom electrode is formed on this substrate 10.

As a material for the bottom electrode, Al or an Al alloy is used.

In this case, an Al-Nd alloy doped with Nd by 2 atomic weight % is used.

In addition, for example, sputtering is used for the formation of the metal film, a film thickness of which is 300 nm.

After the metal film is formed, stripe-shaping bottom electrodes 11 are formed by etching as shown in Fig. 2.

As etching, for example, wet etching by a mixed solution of phosphoric acid, acetic acid, and nitric acid is employed.

Next, a part on the bottom electrode 11, which is used as an electron-emitting portion, is masked by a resist film 17. Then, for a part other than the electron-emitting portion on the bottom electrode 11, thick anodic oxidation is selectively performed in a forming solution using the bottom electrode 11 as an anode to form the protection-insulating layer 14 as shown in Fig. 3.

In this case, if the forming voltage is 100 V, the protection-insulating layer 14 having a thickness of about 136 nm is formed.

After the protection-insulating layer 14 is formed, the resist film 17 is removed. Then, anodic oxidation is

performed again using the bottom electrode 11 as an anode in a forming solution to forms the tunneling insulator 12 on the bottom electrode 11 as shown in Fig. 4.

In this case, for example, if the forming voltage is 6 V, the tunnel-insulating layer 12 having a thickness of about 10 nm is formed on the bottom electrode 11.

Next, as shown in Fig. 5, the bus electrode film, which is used as a feeder line leading to the top electrode 13, is formed by sputtering.

Here, as this bus electrode film, a laminated film made of a metal film used as the bus electrode lower layer (thin film electrode according to the present invention) 15 and a metal film used as the bus electrode upper layer (thick film electrode according to the present invention) 16 is employed; as a material for the bus electrode lower layer, tungsten (W) is employed; and as a material for the bus electrode upper layer, Al-Nd alloy is employed.

In addition, an upper limit of a film thickness of the metal film used as the bus electrode lower layer 15 is set to ten times as thick as a film thickness of the top electrode 13 so that the top electrode 13 to be formed later is not broken at the sharp edge of the bus electrode lower layer 15. To be more specific, the metal film is made as thin as about from several nm to several tens of nm. On the other hand, the metal film used as the bus electrode

upper layer 16 is formed as thick as about hundreds of nm in order to provide sufficient low resistance.

The lower limit of thickness may be set to a thickness that permits the metal film to function as a conductor. About one tenth of a film thickness of the top electrode 13 is preferable.

Subsequently, as shown in Fig. 6, the bus electrode upper layer 16 is processed in a stripe shape in the direction orthogonal to the bottom electrode 11 by a photolithography process and an etching process.

In this case, for example, the mixed solution of phosphoric acid, acetic acid, and nitric acid is employed for etching.

Next, as shown in Fig. 7, the bus electrode lower layer 15 is processed by the photolithography process and the etching process in a similar manner.

What should be noted at this point of time is that in order to get electric contact with the top electrode 13, which will be made later in the electron emitting portion, the bus electrode lower layer 15 is processed so as to extend off the bus electrode upper layer 16.

It is to be noted that a mixed solution of ammonia and hydrogen peroxide is suitable for etching of tungsten (W).

Lastly, as shown in Fig. 8, the top electrode 13 is

formed. As a result, the thin film type electron emitter according to this embodiment is completed.

The patterning of this top electrode 13 is performed by lift-off; and the formation of the top electrode 13 is performed by sputtering.

As the top electrode 13, for example, a laminated film of iridium (Ir), platinum (Pt), and gold (Au) is employed; and each film thickness is several nm. The formation is performed by sputtering as described above.

In this embodiment, the metal film used as the bus electrode upper layer 16 is formed by sputtering. However, the present invention is not limited to this. The metal film used as the bus electrode upper layer 16 may be formed by any of electroplating, vacuum evaporation, chemical vapor deposition, and screen-printing.

The thin film type electron emitter according to this embodiment has the bus electrode upper layer 16 that is formed as thick as about hundreds of nm. Therefore, sheet resistance of a bus electrode constituting a feeder line can be decreased by about two digits as compared with sheet resistance of the top electrode 13 (about 200Ω/□), which enables a decrease in resistance of the bus electrode.

Moreover, since the bus electrode lower layer 15 is formed so as to have a film thickness ranging from several nm to several tens of nm, it is possible to prevent the top

electrode 13 from being broken at the edge of the bus electrode lower layer 15.

[Second Embodiment]

The thin film type electron emitter according to the second embodiment of the present invention is characterized in that the top electrode 13 also serves as the bus electrode lower layer, and that the bus electrode upper layer 16 is formed on the top electrode by sputtering.

A method for manufacturing the thin film type electron emitter according to this embodiment will be described below with reference to Figs. 9 to 11.

Incidentally, Figs. 9(a) to 11(a) each are a plan view; Figs. 9(b) to 11(b) each are a cross section that illustrates a cross-sectional structure along the cutting plane line A-A' of Fig. 9(a); and Figs. 9(c) to 11(c) each are a cross section that illustrates a cross-sectional structure along the cutting plane line B-B' of Fig. 9(a).

To begin with, as is the case with the first embodiment, formation is performed up to the tunnel-insulating layer 12 using the method shown in Figs. 2 to 4.

Next, as shown in Fig. 9, a metal film used as the top electrode 13 and a metal film used as the bus electrode upper layer 16 are formed in this order by sputtering.

As a material of the metal film used as the top electrode 13, for example, a laminated film made of

tungsten (W), platinum (Pt), and gold (Au) is employed; and each film thickness ranges from 1 to 3 nm.

The Al-Nd alloy described above is accumulated on the metal film used as the bus electrode upper layer 16 by hundreds of nm.

Subsequently, a resist pattern is formed by the photolithography process, and then Al-Nd alloy other than the bus electrode upper layer is removed by wet etching to form the bus electrode upper layer 16 as shown in Fig. 10.

The above-mentioned mixed solution of phosphoric acid, acetic acid, and nitric acid is suitable for etching.

Lastly, the electron-emitting portion is covered with a resist pattern, and then a metal film used for the top electrode in the bus electrode upper layer is removed to form the top electrode 13 as shown in Fig. 11. As a result, the thin film type electron emitter according to this embodiment is completed.

Concerning etching, aqua regia is suitable for platinum (Pt) and gold (Au); and the above-mentioned mixed solution of ammonia and hydrogen peroxide is suitable for tungsten (W).

It is to be noted that in this embodiment, the metal film used as the bus electrode upper layer 16 may also be formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

The thin film type electron emitter according to this embodiment has the bus electrode upper layer 16 that is formed as thick as about hundreds of nm. Therefore, sheet resistance of the bus electrode constituting a feeder line can be decreased by about two digits as compared with sheet resistance of the top electrode 13 (about 200Ω/□), which enables a decrease in resistance of the bus electrode.

In addition, since the top electrode 13 is also used as the bus electrode lower layer, it is possible to prevent the top electrode 13 from being broken in level in the electron-emitting portion.

[Third Embodiment]

The thin film type electron emitter according to the third embodiment of the present invention is characterized in that the top electrode 13 also serves as the bus electrode lower layer, and that the bus electrode upper layer 16 is formed on the top electrode by electroplating.

A method for manufacturing the thin film type electron emitter according to this embodiment will be described below with reference to Figs. 12 to 14.

Incidentally, Figs. 12(a) to 14(a) each are a plan view; Figs. 12(b) to 14(b) each are a cross section that illustrates a cross-sectional structure along the cutting plane line A-A' of each of Figs. 12(a) to 14(a); and Figs. 12(c) to 14(c) each are a cross section that illustrates a

cross-sectional structure along the cutting plane line B-B' each of Figs. 12(a) to 14(a).

To begin with, as is the case with the first embodiment, formation is performed up to the tunnel-insulating layer 12 using the method shown in Figs. 2 to 4.

Next, as shown in Fig. 12, a metal film, which is used as the top electrode 13, is formed by sputtering.

As a material used for the top electrode, for example, a laminated film of tungsten (W), platinum (Pt), and gold (Au) is employed; and each film thickness ranges from 1 to 3 nm.

Subsequently, a part on which the bus electrode upper layer 16 is not formed is covered by a resist pattern, and then a gold (Au) film is grown as a backing electrode by gold electroplating to form the bus electrode upper layer 16 as shown in Fig. 13.

Lastly, an electron-emitting portion is covered with a resist pattern, and then a metal film used for the top electrode in the bus electrode upper layer is removed to form the top electrode 13 as shown in Fig. 14. As a result, the thin film type electron emitter according to this embodiment is completed.

Concerning etching, aqua regia is suitable for platinum (Pt) and gold (Au); and the above-mentioned mixed solution of ammonia and hydrogen peroxide is suitable for

tungsten (W).

It is to be noted that in this embodiment, the bus electrode upper layer 16 may also be formed by any of sputtering, vacuum evaporation, chemical vapor deposition, and screen-printing.

However, as described in this embodiment, if the gold (Au) film is grown as a backing electrode by gold electroplating to form the bus electrode upper layer 16, adherence between the top electrode 13 and the bus electrode upper layer 16 becomes excellent, and a film thickness of the bus electrode upper layer 16 can be set arbitrarily. In addition, the damage to the tunnel-insulating layer 12 can be reduced as compared with other processes.

The thin film type electron emitter according to this embodiment has the bus electrode upper layer 16 that is formed as thick as about hundreds of nm. Therefore, sheet resistance of the bus electrode constituting a feeder line can be decreased by about two digits as compared with sheet resistance of the top electrode 13 (about 200Ω/□), which enables a decrease in resistance of the bus electrode.

In addition, since the top electrode 13 is also used as the bus electrode lower layer, it is possible to prevent the top electrode 13 from being broken in the electron-emitting portion.

[Fourth Embodiment]

The thin film type electron emitter according to the fourth embodiment of the present invention is characterized in that the top electrode 13 is electrically connected to the bus electrode lower layer 15, and that the bus electrode upper layer 16 is formed on the bus electrode lower layer 15 by electroplating.

A method for manufacturing the thin film type electron emitter according to this embodiment will be described below with reference to Figs. 15 to 18.

Incidentally, Figs. 15(a) to 18(a) each are a plan view; Figs 15(b) to 18(b) each are a cross section that illustrates a cross-sectional structure along the cutting plane line A-A' of each of Figs. 15(a) to 18(a); and Figs. 15(c) to 18(c) each are a cross section that illustrates a cross-sectional structure along the cutting plane line B-B' each of Figs. 15(a) to 18(a).

To begin with, as is the case with the first embodiment, formation is performed up to the tunnel-insulating layer 12 using the method shown in Figs. 2 to 4.

Next, as shown in Fig. 15, a metal film, which is used as the bus electrode lower layer 15, is formed by sputtering.

As a material of the metal film used as the bus electrode lower layer 15, for example, a laminated film of

tungsten (W) and gold (Au) is employed; and it is desirable that each film thickness is about 10 nm.

Subsequently, a part on which the bus electrode upper layer 16 is not formed is covered with a resist pattern, and then a gold (Au) film is grown as a backing electrode by gold electroplating to form the bus electrode upper layer 16 as shown in Fig. 16.

Next, as shown in Fig. 17, the bus electrode lower layer 15 is processed by the photolithography process and the etching process.

What should be noted at this point of time is that in order to get electric contact with the top electrode 13, which will be made later in an electron emitting portion, the bus electrode lower layer 15 is processed so as to extend off the bus electrode upper layer 16.

Aqua regia is used for etching of gold (Au); and the above-mentioned mixed solution of ammonia and hydrogen peroxide is used for etching of tungsten (W).

Lastly, as shown in Fig. 18, the top electrode 13 is formed. As a result, the thin film type electron emitter according to this embodiment is completed.

The patterning of the top electrode 13 is performed by lift-off; and the formation of the top electrode 13 is performed by sputtering.

As the top electrode 13, for example, a laminated

film of iridium (Ir), platinum (Pt), and gold (Au) is employed; and each film thickness is several nm. The film formation is performed by sputtering as described above.

It is to be noted that in this embodiment, the metal film used as the bus electrode upper layer 16 may also be formed by any of sputtering, vacuum evaporation, chemical vapor deposition, and screen-printing.

The thin film type electron emitter according to this embodiment has the bus electrode upper layer 16 that is formed as thick as about hundreds of nm. Therefore, sheet resistance of the bus electrode constituting a feeder line can be decreased by about two digits as compared with sheet resistance of the top electrode 13 (about 200Ω/□), which enables a decrease in resistance of the bus electrode.

Moreover, because the bus electrode lower layer 15 is thinly formed so as to have a thickness approximately ranging from several nm to several tens of nm, it is possible to prevent the top electrode 13 from being broken at the sharp edge of the bus electrode lower layer 15.

In each of the embodiments, the present invention was applied to the thin film type electron emitter as described above. However, the present invention is not limited to this. It is needless to say that the present invention can also be applied to a surface conduction type electron source, for example.

[Fifth Embodiment]

Fig. 19 is a schematic diagram illustrating a configuration of the thin film type electron emitter array substrate of the display device according to the fifth embodiment of the present invention.

Fig. 19 (a) is a plan view illustrating the thin film type electron emitter array substrate according to this embodiment. Fig. 19 (b) is a cross section substantially illustrating a cross-sectional structure along the line A-A' in Fig. 19 (a); and Fig. 19 (c) is a cross section substantially illustrating a cross-sectional structure along the line B-B' in Fig. 19 (a).

In this embodiment, the thin film type electron emitter according to the first embodiment is used as the thin film type electron emitter array substrate. However, the thin film type electron emitter according to the second embodiment to the fourth embodiment may also be used.

The thin film type electron emitter array substrate according to this embodiment has a configuration in which the thin film type electron emitter is formed on a substrate 10 in a matrix form according to the steps described in the first embodiment.

Fig. 19 illustrates the thin film type electron emitter matrix (3 x 3 dots) having a structure of three bottom electrodes 11 by three top electrodes bus lines 17.

However, in reality, thin film type electron emitters in a matrix are formed corresponding to the number of displayed dots.

Further, in reality, the bus electrode has a laminated structure of the bus electrode lower layer 15 and the bus electrode upper layer 16. However, the bus electrode is illustrated as a whole as the laminated bus electrode 18 in Fig. 19.

Incidentally, although it has not been described in each of the embodiments, if the thin film type electron emitter matrix is used for the display device, the surfaces of electrode edges of the bottom electrode 11 and the upper part bus electrode 18 must be exposed for circuit connection.

Fig. 20 is a diagram schematically illustrating a configuration of the phosphor plate of the display device according to the fifth embodiment of the present invention.

Fig. 20 (a) is a plan view illustrating the phosphor plate according to this embodiment. Fig. 20 (b) is a cross section substantially illustrating a cross-sectional structure along the line A-A' in Fig. 20 (a); and Fig. 20 (c) is a cross section substantially illustrating a cross-sectional structure along the line B-B' in Fig. 20 (a).

The phosphor plate according to this embodiment comprises the following: a black matrix 120 formed on a

substrate 110 such as soda lime; red (R) phosphor 111, green (G) phosphor 112, and blue (B) phosphor 113 that are formed in grooves of the black matrix 120; and a metal back film 114 formed on them.

A method for producing the phosphor plate according to this embodiment will be described below.

In the first place, for the purpose of increasing the contrast of the display device, the black matrix 120 is formed on the substrate 110.

The black matrix 120 is formed by the following steps: applying a solution, in which polyvinyl alcohol (PVA: hereinafter merely referred to as PVA) and ammonium chromate are mixed, to the substrate 110; after irradiating an area other than a part, on which the black matrix 120 is formed, with ultraviolet rays so that the non-exposed area is removed by running water; and applying a solution, in which graphite powder is dissolved, to the unexposed part to lift off PVA.

Next, the red phosphor 111 is formed by a method described below.

After applying an aqueous solution, in which red phosphor particles, PVA, and ammonium chromate are mixed, to the substrate 110, a part on which phosphor is formed is irradiated with ultraviolet rays so that the part is exposed. Then, the unexposed part is removed by running

water.

In this manner, the red phosphor 111 is patterned.

Although the phosphor pattern is a stripe-shaped pattern as shown in Fig. 20, this stripe pattern is merely one example. It is to be noted that other than this example, according to display design, for example, even a "RGBG" pattern in which four adjacent dots constitute one pixel may also be applied as a matter of course.

Using a similar method, the green phosphor 112 and the blue phosphor 113 are formed.

In this case, the following are employed as phosphor, for example: Y_2O_2S: Eu (P22-R) as the red phosphor 111; ZnS: Cu, Al (P22-G) as the green phosphor 112; and ZnS: Ag (P22-B) as the blue phosphor 113.

Next, after filming with a film such as nitrocellulose, Al is evaporated onto the whole substrate 110 until Al has a film thickness of about 75 nm. As a result, the metal back film 114 is formed. This metal back film 114 acts as an accelerating electrode.

After that, the substrate 110 is heated to about 400 ℃ in the air so that organic matter such as a filming film and PVA is decomposed by heating.

In this manner, the phosphor plate is completed.

Fig. 21 is a cross section schematically illustrating a whole configuration of the display device

according to the fifth embodiment of the present invention.

Fig. 21 (a) is a cross section substantially illustrating a cross-sectional structure along the line A-A' in Fig. 19 (a) and Fig. 20 (a); and Fig. 21 (b) is a cross section substantially illustrating a cross-sectional structure along the line B-B' in Fig. 19 (a) and Fig. 20 (a).

As shown in Fig. 21, the thin film type electron emitter array substrate produced by the steps described above, the phosphor plate, and a frame glass 116 are assembled through spacers 30 before the frame glass 116 is sealed using flit glass 115.

A height of the spacers 30 is set so that a distance between the thin film type electron emitter array substrate and the phosphor plate ranges from 1 to 3 mm.

The spacer 30 is made of plate glass or ceramic, for example. The spacer 30 is placed between the laminated bus electrodes 18.

In this case, because the spacer 30 is placed under the black matrix 120 of the phosphor plate, the spacer 30 does not block light emission.

Therefore, existence of the spacer 30 hardly causes degradation of image quality.

Here, for the purpose of a description, the spacer 30 is provided at each dot that emits light in R (red), G

(green), or B (blue), that is to say, at all positions between the laminated bus electrodes 18. However, in reality, the number (density) of the spacers 30 may be decreased within the range of mechanical strength. Therefore, providing the spacers 30 at intervals of about 1 cm suffices.

In addition, even if a pillar type spacer or a cross type spacer is employed as the spacer 30 in this embodiment, panel assembling is possible using a similar technique.

The sealed panel is evacuated to a vacuum of about 10^{-7} Torr before sealed.

After the sealing, getter is activated to maintain a vacuum in the panel.

For example, in the case of a getter material, the main component of which is barium (Ba), a getter film can be formed by high-frequency induction heating, or the like.

Further, non-evaporate getter, the main component of which is zirconium (Zr), may also be employed.

In this manner, the display device according to this embodiment is completed.

In the display device according to this embodiment, a distance between the thin film type electron emitter array substrate and the phosphor plate is as long as approximately ranging from 1 to 3 mm. Because of it, acceleration voltage that is applied to the metal back film

114 can be made as high as 3 to 6 KV.

Accordingly, as described above, phosphor used for cathode ray tube (CRT) can be employed as the phosphor.

According to the display device of this embodiment, even if many of the thin film type electron emitters are aligned in an array shape to constitute a cold cathode type phosphor display device having a 40-inch-class large screen, resistance of the bus electrode which constitutes a feeder line can be decreased, which permits each of the thin film type electron emitter element to operate without poor brightness uniformity. Therefore, it is possible to prevent poor brightness uniformity on the display screen.

Fig. 22 is a schematic diagram illustrating a state in which drive circuits are connected to the display device according to this embodiment.

The bottom electrode 11 is driven by a bottom electrode drive circuit 40; and the laminated bus electrode 18 is driven by a top electrode drive circuit 50.

In this case, each of the drive circuits (40, 50) is connected to the thin film type electron emitter array substrate using the following: for example, a tape carrier package crimped with an anisotropic conductive film; a chip on glass in which a semiconductor chip constituting each drive circuit (40, 50) is directly mounted on the substrate (for example, glass) of the thin film type electron emitter

array substrate; or the like.

An acceleration voltages ranging from 3 to 6 KV is always applied to the metal back film 114 from a high voltage supply 60.

Fig. 23 is a timing chart illustrating an example of the waveform of driving voltage that is output by each of the drive circuits shown in Fig. 22.

Here, assumed that the mth bottom electrode 11 is expressed as Km; the nth laminated bus electrode 18 is expressed as Cn; and an intersection point of the mth bottom electrode 11 and the nth laminated bus electrode 18 is expressed as (m, n).

At time t0, the driving voltage of both electrodes is zero, causing no electron to be emitted. Therefore, phosphor does not emit light.

At time t1, the driving voltage of (-V1), which is output from the bottom electrode drive circuit 40, is applied to the bottom electrode 11 of K1; and the driving voltage of (+V2), which is output from the top electrode drive circuit 50, is applied to the laminated bus electrode 18 of (C1, C2).

Since the voltage of (V1 + V2) is applied between the bottom electrode 11 and the top electrode 13 at the intersection points (1, 1) and (1, 2), if the voltage of (V1 + V2) is set at a value higher than starting voltage of

electron emission, electrons are emitted into a vacuum from the thin film type electron emitters at these two intersection points.

The emitted electrons are accelerated by the acceleration voltage from the high voltage supply 60, which is applied to the metal back film 114. Then, the emitted electron enters into the phosphor (111 through 113) to emit light.

At time t2, the driving voltage of (-V1), which is output from the bottom electrode drive circuit 40, is applied to the bottom electrode 11 of K2; and the driving voltage of (+V2), which is output from the top electrode drive circuit 50, is applied to the laminated bus electrode 18 of (C1). As a result, the intersection point (2, 1) emits light similarly.

In this manner, changing the signal that is applied to the laminated bus electrode 18 permits desired image or information to be displayed.

Moreover, properly changing the level of driving voltage (+V2) which is applied to the laminated bus electrode 18 permits a gray scale image to be displayed.

It is to be noted that reverse bias for discharging electric charges accumulated in the tunnel insulating layer 12 is applied by the following method: after applying the driving voltage of (-V1), which is output from the bottom

electrode drive circuit 40, to all of the bottom electrodes 11, applying a driving voltage of (+V3), which is output from the bottom electrode drive circuit 40, to all of the bottom electrodes 11, and applying a driving voltage of (-V3'), which is output from the top electrode drive circuit 50, to all of the laminated bus electrodes 18.

The invention devised by this inventor was specifically described on the basis of the embodiments as above. However, the present invention is not limited to the embodiments. As a matter of course, the present invention can be changed in various ways within the range that does not deviate from points thereof.

INDUSTRIAL APPLICABILITY

Effects, which can be obtained from typical features of the present invention disclosed in this application concerned, will be briefly described below.

(1) According to the electron source of the present invention, the bus electrode for power supply, which applies driving voltage to the electron source element, has a laminated structure comprising a thin film electrode, and a thick film electrode with low resistance that is backed on this thin film electrode. Therefore, sheet resistance of the bus electrode can be reduced by about two digits as compared with sheet resistance of the top electrode, which

enables reduction in resistance of the bus electrode.

In addition, since the thin film electrode is thinly formed so as to have a film thickness that is almost the same as that of the electrode of the electron source, it is possible to prevent the electrode of the electron source from being broken along with the edge of the thin film electrode in the electron emitting portion.

(2) According to the display device of the present invention, even if a 40-inch-class large screen is used, resistance of the bus electrode which constitutes a feeder line can be decreased, and thereby it is possible to prevent poor brightness uniformity on the display screen.

CLAIMS

1. An electron source comprising:

a plurality of electron source elements; and

a plurality of bus electrodes that apply driving voltage to an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that is less than or equal to a film thickness of the electrode of the electron source element; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

2. An electron source according to claim 1, wherein the thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

3. A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface

of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode electrically connected to the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

4. A thin film type electron emitter according to claim 3, wherein the thin film electrode has a film thickness that is less than or equal to ten times as thick as a film thickness of the top electrode.

5. A thin film type electron emitter according to claim 4, wherein each of the thin film electrode and the thick film electrode has an open area where the insulating layer is exposed;

the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode; and

the top electrode is provided so as to cover the thin film electrode that is exposed in the open area

provided in the thick film electrode.

6. A thin film type electron emitter according to any of claims 3 to 5, wherein the thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen printing.

7. A thin film type electron emitter comprising:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

wherein each of the bus electrodes comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

8. A thin film type electron emitter according to claim 7, wherein the thick film electrode has an open area that is provided in an area where the insulating layer is

formed.

9. A thin film type electron emitter according to claim 7 or 8, wherein the thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

10. A method for manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying a positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode electrically connected to the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of forming a thick conductive film on the thin conductive film;

a step 5 of forming the thick film electrode by selectively patterning the thick conductive film;

a step 6 of forming the thin film electrode by selectively patterning the thin conductive film; and

a step 7 of forming a top electrode that is electrically connected to the thin film electrode.

11. A method of manufacturing a thin film type electron emitter according to claim 10, wherein in the step 3 of forming the thin conductive film, the thin conductive film is formed so that a film thickness of the thin conductive film becomes less than or equal to ten times as thick as a film thickness of the top electrode.

12. A method of manufacturing a thin film type electron emitter according to claim 10 or 11, wherein in the step 5 of selectively patterning the thick conductive film, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 6 of selectively patterning the thin conductive film, an open area where the insulating layer is exposed is formed in the thin film electrode inside the open area which is formed in the thick film electrode; and

in the step 7 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode

that is exposed in the open area provided on the thick film electrode.

13. A method for manufacturing a thin film type electron emitter according to any of claims 10 to 12, wherein in the step 4 of forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

14. A method for manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode electrically connected to the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of selectively forming a thick film electrode on the thin conductive film;

a step 5 of forming the thin film electrode by selectively patterning the thin conductive film; and

a step 6 of forming a top electrode that is electrically connected to the thin film electrode.

15. A method of manufacturing a thin film type electron emitter according to claim 14, wherein in the step 3 of forming the thin conductive film, the thin conductive film is formed so that a film thickness of the thin conductive film becomes less than or equal to ten times as thick as a film thickness of the top electrode.

16. A method of manufacturing a thin film type electron emitter according to claim 14 or 15, wherein in the step 4 of selectively forming the thick film electrode, an open area where the insulating layer is exposed is formed in the thick film electrode;

in the step 5 of selectively patterning the thin conductive film, an open area where the insulating layer is exposed is formed in the thin film electrode; and

in the step 6 of forming the top electrode, the top electrode is formed so as to cover the thin film electrode

that is exposed in the open area provided on the thick film electrode.

17. A method of manufacturing a thin film type electron emitter according to any of claims 14 to 16, wherein in the step 4 of selectively forming the thick film electrode, the thick film electrode is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

18. A method of manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode integrated with the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of forming a thick conductive film on the thin conductive film;

a step 5 of forming the thick film electrode by selectively patterning the thick conductive film; and

a step 6 of forming the thin film electrode and the top electrode by selectively patterning the thin conductive film.

19. A method for manufacturing a thin film type electron emitter according to claim 18, wherein in the step 5 of selectively patterning the thick conductive film, an open area where the insulating layer is exposed is formed in the thick film electrode.

20. A method of manufacturing a thin film type electron emitter according to claim 18 or 19, wherein in the step 4 of forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen-printing.

21. A method of manufacturing a thin film type electron emitter comprising: a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an

electron from a surface of the top electrode when applying positive voltage to the top electrode; and a plurality of bus electrodes comprising a thin film electrode integrated with the top electrode, and a thick film electrode that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode, said plurality of bus electrodes applying driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements,

said method comprising:

a step 1 of forming the bottom electrode;

a step 2 of forming the insulating layer;

a step 3 of forming a thin conductive film on the bottom electrode and the insulating layer;

a step 4 of selectively forming a thick film electrode on the thin conductive film; and

a step 5 of forming the thin film electrode and the top electrode by selectively patterning the thin conductive film.

22. A method of manufacturing a thin film type electron emitter according to claim 21, wherein in the step 4 of selectively forming the thick film electrode, an open area where the insulating layer is exposed is formed in the thick film electrode.

23. A method of manufacturing a thin film type

electron emitter according to claim 21 or 22, wherein in the step 4 of selectively forming the thick conductive film, the thick conductive film is formed by any of plating, sputtering, vacuum evaporation, chemical vapor deposition, and screen printing.

24. A display device comprising:

a first substrate comprising a plurality of electron source elements, and a plurality of bus electrodes applying driving voltage to an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to an electrode of each of the electron source elements, said thin film electrode having a film thickness that is less than or equal to a film thickness of the electrode of the electron source element; and

a thick film electrode electrically connected to the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

25. A display device according to claim 24, wherein the thick film electrode is a metallic layer that is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

26. A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor,

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum atmosphere; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode electrically connected to the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

27. A display device according to claim 26, wherein the thin film electrode has a film thickness that is less than or equal to ten times as thick as a film thickness of the top electrode.

28. A display device according to claim 26 or 27, wherein each of the thin film electrode and the thick film electrode has an open area where the insulating layer is exposed;

the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode; and

the top electrode is provided so as to cover the thin film electrode that is exposed in the open area provided in the thick film electrode.

29. A display device according to any of claims 26 to 28, wherein the thick film electrode is a metallic layer that is formed by any of one of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

30. A display device comprising:

a first substrate including:

a plurality of electron source elements, each of which has a structure in which a bottom electrode, an

insulating layer, and a top electrode are laminated in this order, and each of which emits an electron from a surface of the top electrode when applying positive voltage to the top electrode; and

a plurality of bus electrodes that apply a driving voltage to a top electrode of an electron source element in a first direction among the plurality of electron source elements;

a frame glass; and

a second substrate having phosphor;

wherein a space surrounded by the first substrate, the frame glass, and the second substrate is allowed to be a vacuum; and

wherein each bus electrode of the first substrate comprises:

a thin film electrode that is integrated with the top electrode; and

a thick film electrode provided on the thin film electrode, said thick film electrode having a film thickness thicker than that of the thin film electrode.

31. A display device according to claim 30, wherein the thick film electrode has an open area that is provided in an area where the insulating layer is formed.

32. A display device according to claim 30 or 31, wherein the thick film electrode is a metallic layer that

is formed by any of plating, vacuum evaporation, chemical vapor deposition, and screen-printing.

ABSTRACT

A thin film type electron emitter comprises a plurality of electron source elements, each of which has a structure in which a bottom electrode (11), an insulating layer (12), and a top electrode (13) are laminated in this order, and each of which emits electron from the surface of the top electrode when applying a positive voltage to the top electrode; and a plurality of the bus electrodes that apply the driving voltage to the top electrode of the electron source element in the first direction among the plurality of electron source elements. Each of the bus electrodes comprises a thin film electrode (15) electrically connected to the top electrode; and a thick film electrode (16) that is provided on the thin film electrode, and that has a film thickness thicker than that of the thin film electrode.

Additionally, the thin film electrode has a film thickness that is almost the same as that of the top electrode. Moreover, each of the thin film electrode and the thick film electrode has an open area where the insulating layer is exposed. In addition to it, the open area, which is provided in the thick film electrode, is larger than the open area provided in the thin film electrode. The top electrode is provided so as to cover

the thin film electrode that is exposed in the open area provided in the thick film electrode.

This prevents an increase in resistance of the bus electrode for power supply that applies the driving voltage to the electron source element, and also prevents the top electrode from being broken along the edge of the thin film electrode in the electron-emitting portion.

FIG. 1

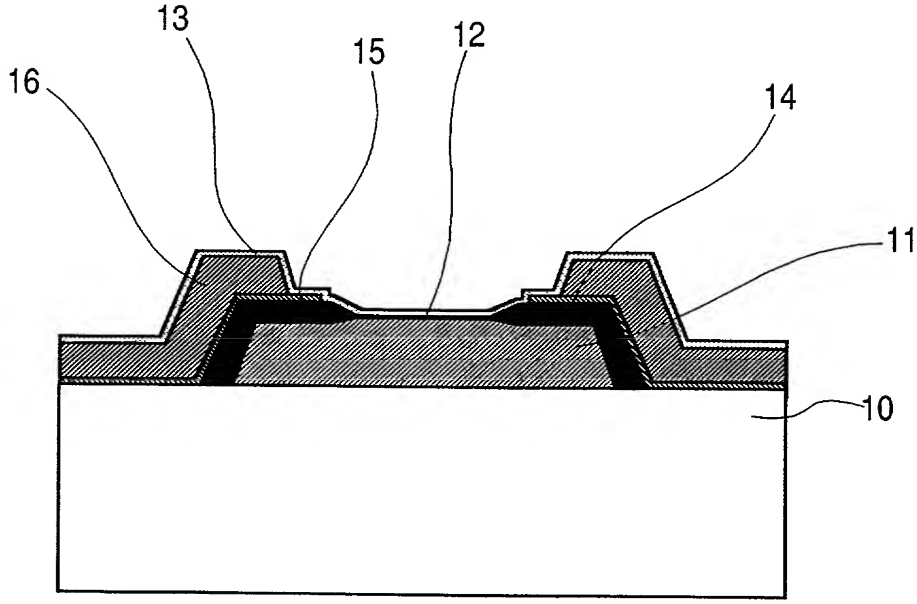
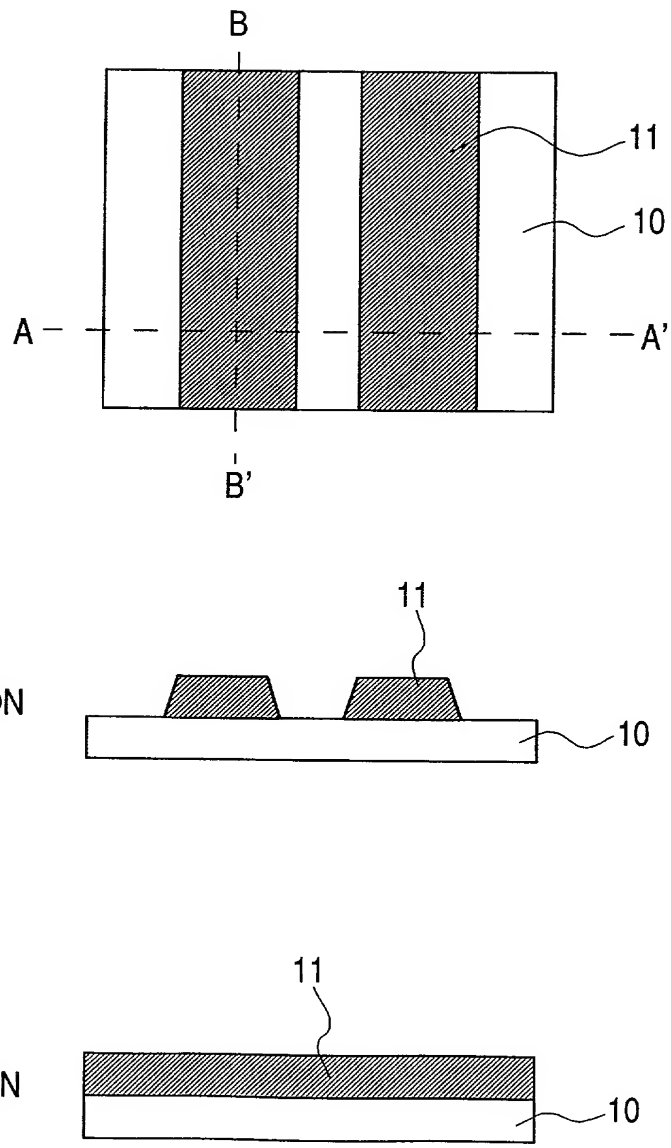


FIG. 2

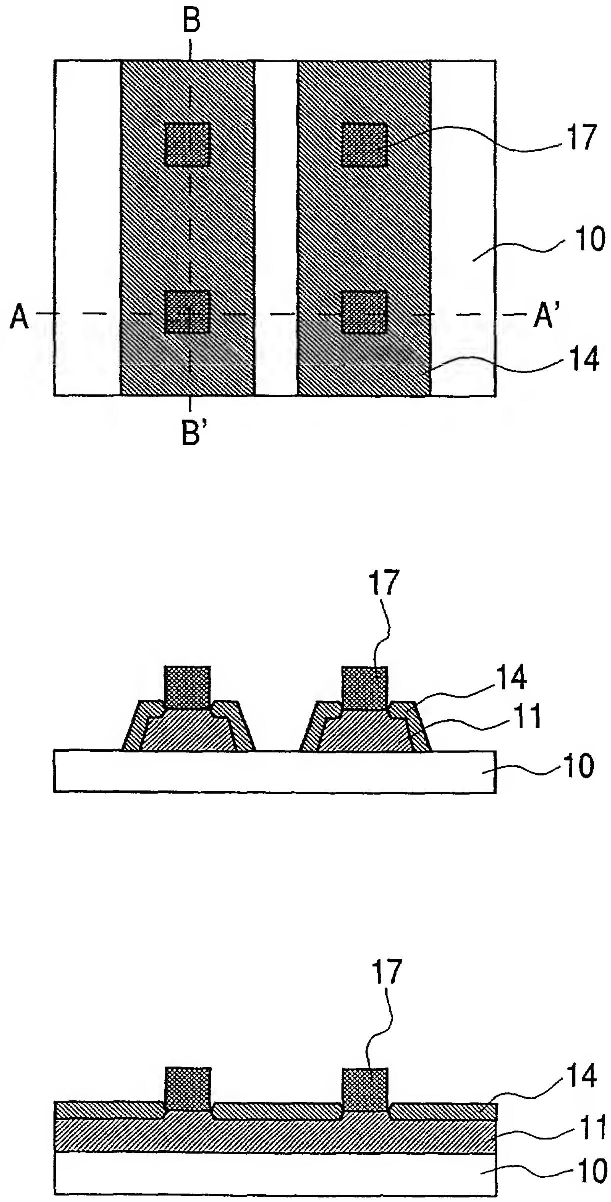


(a)

(b) A—A' SECTION

(c) B—B' SECTION

FIG. 3



(a)

(b) A—A' SECTION

(c) B—B' SECTION

FIG. 4

(a)

(b) A—A' SECTION

(c) B—B' SECTION

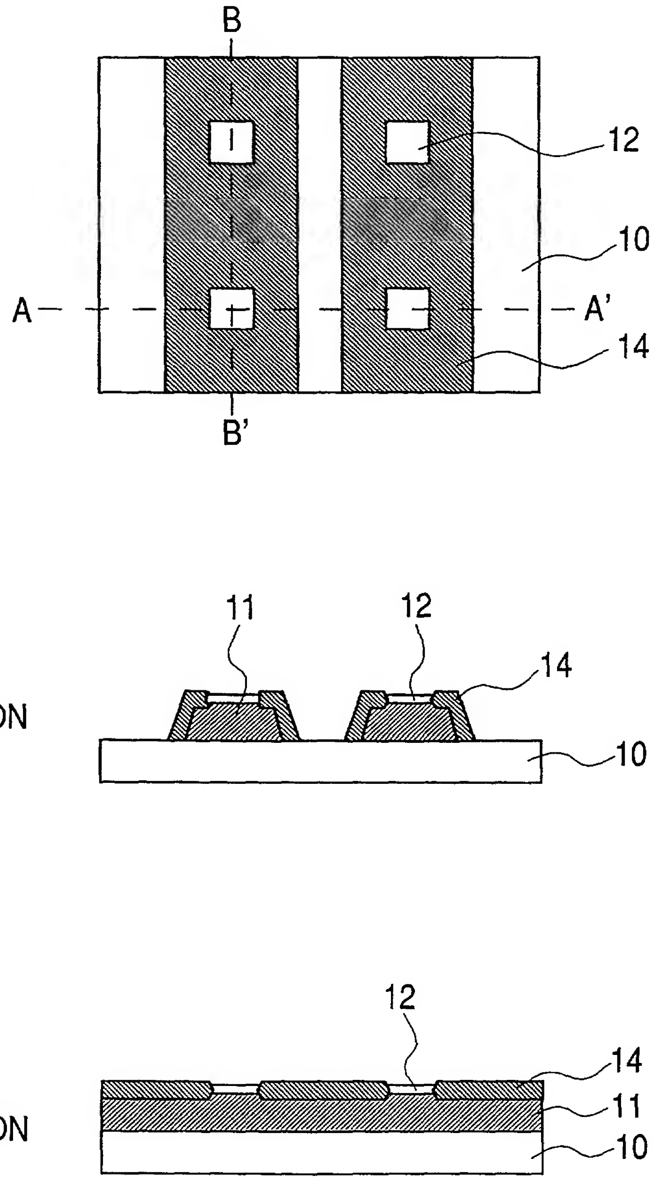
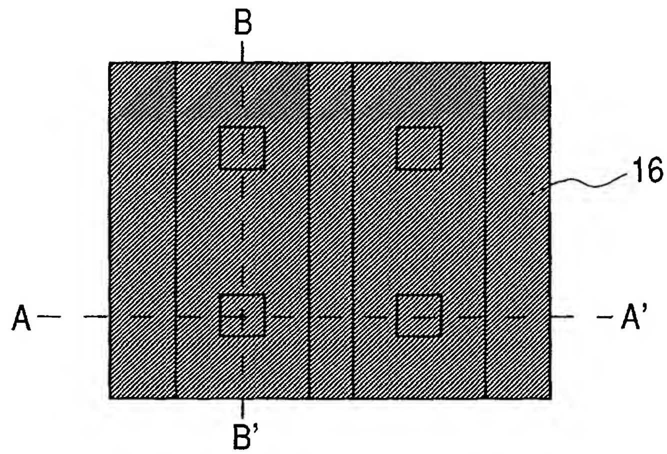
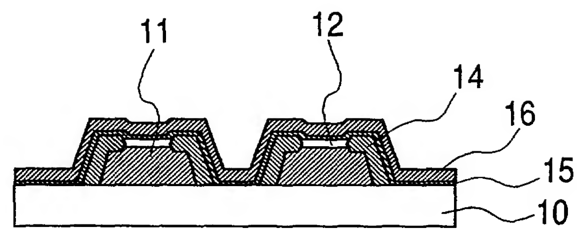


FIG. 5

(a)



(b) A—A' SECTION



(c) B—B' SECTION

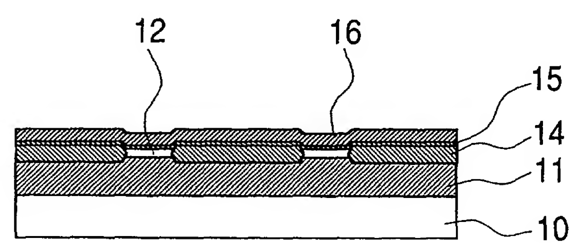


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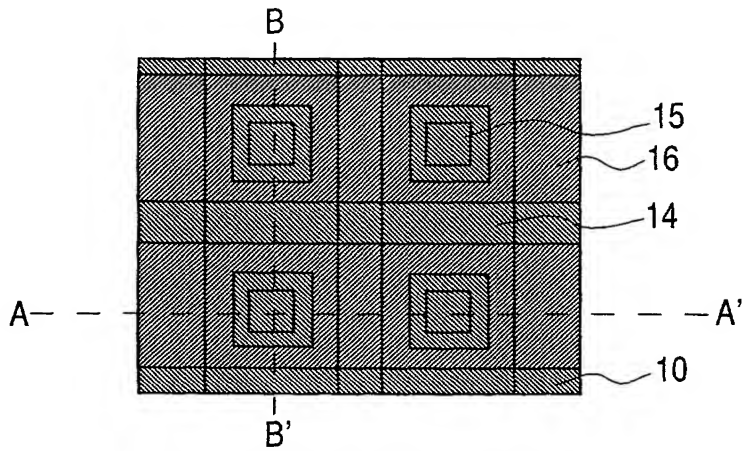
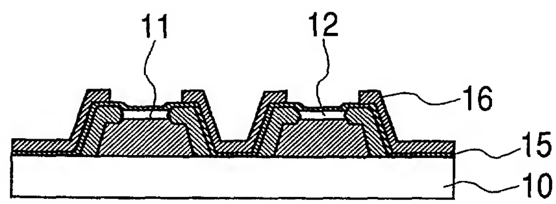
FIG. 6

(a)



(b) A—A' SECTION



(c) B—B' SECTION

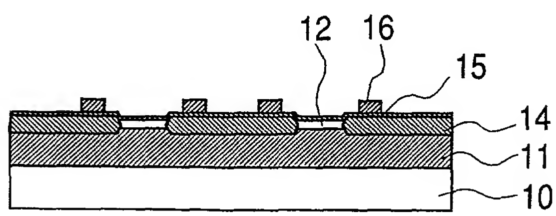


FIG. 7

(a)

(b) A—A' SECTION

(c) B—B' SECTION

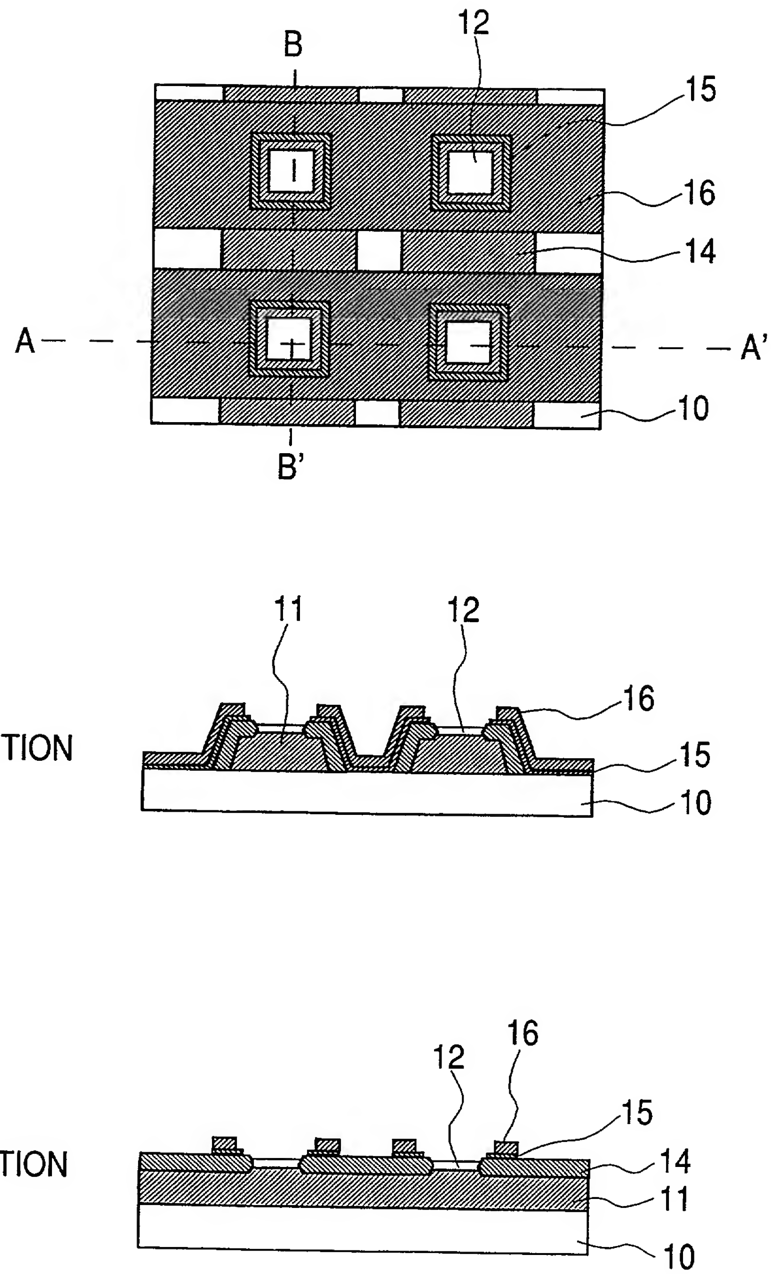


FIG. 8

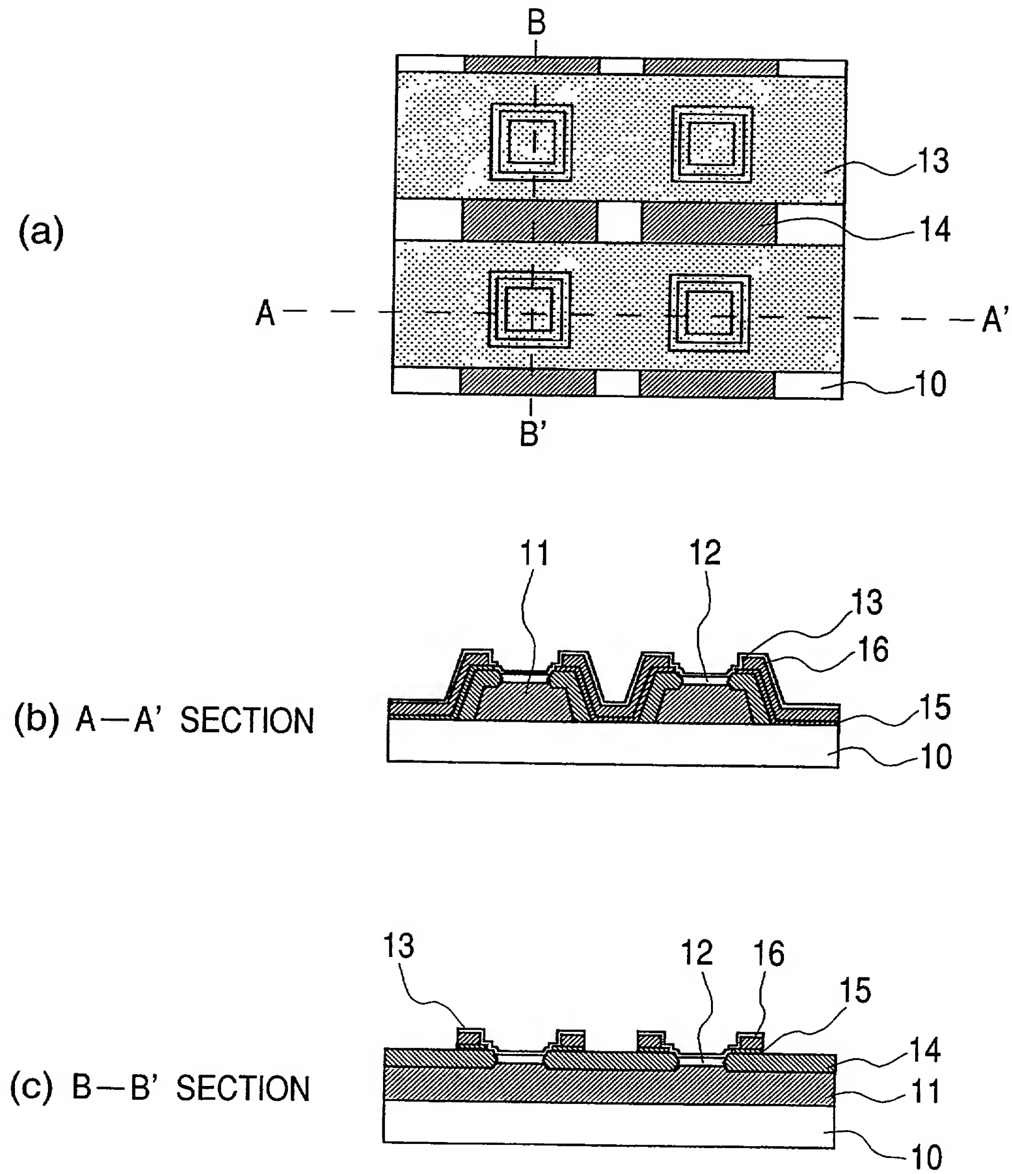

(a)
B
13
14
A
A'
10
B'
(b) A—A' SECTION
11
12
13
16
15
10
(c) B—B' SECTION
13
12
16
15
14
11
10

FIG. 9

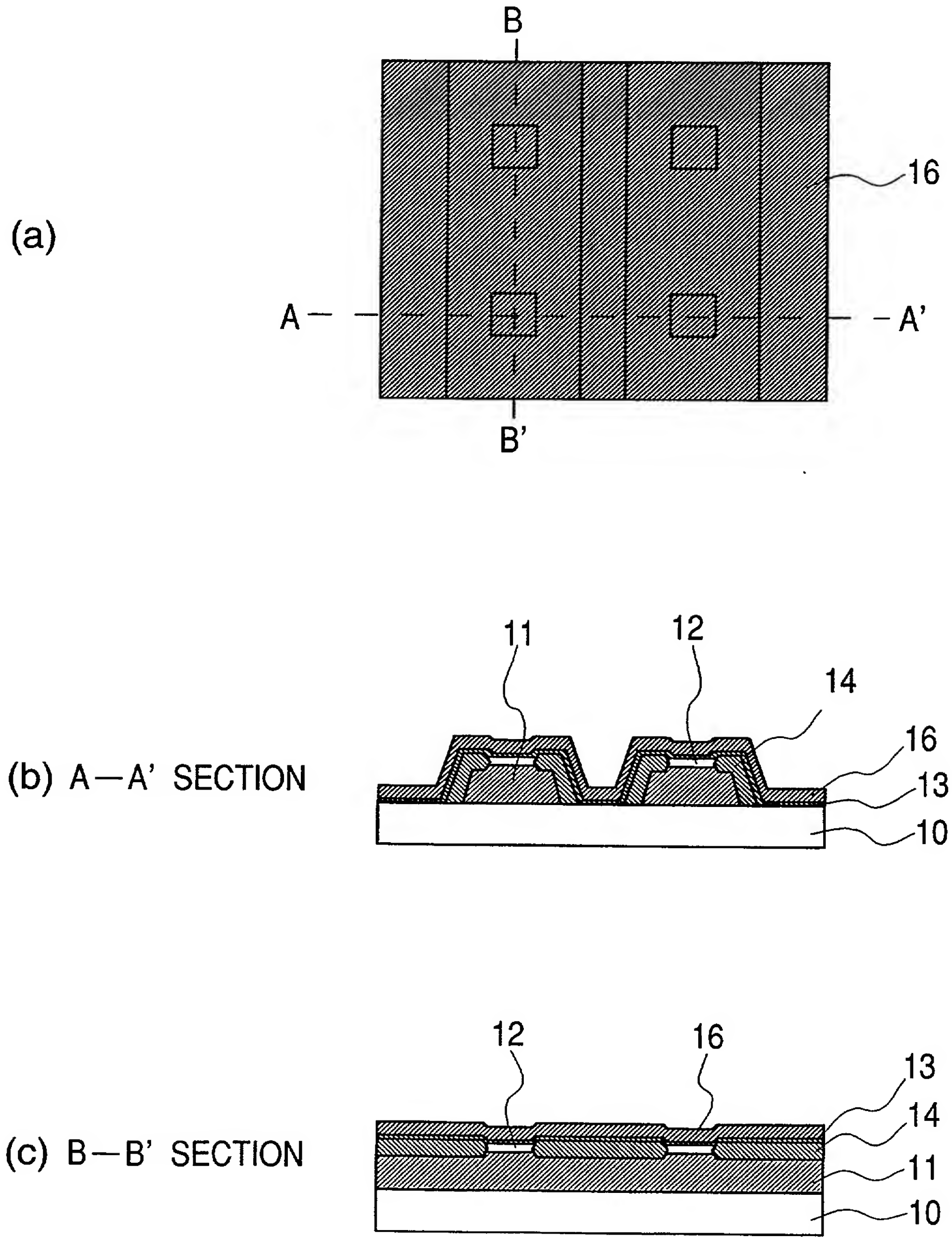
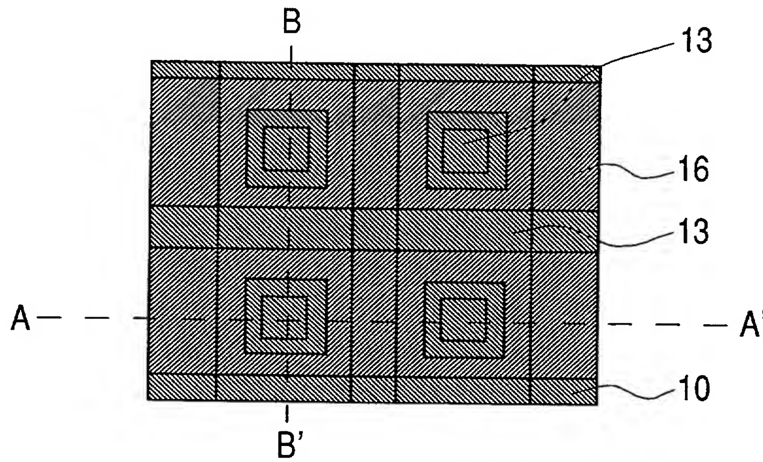
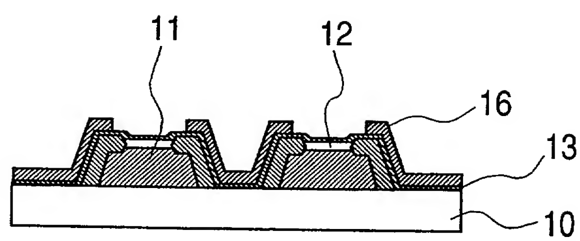

B
16
(a)
A
A'
B'
11
12
14
16
(b) A—A' SECTION
13
10
12
16
13
14
(c) B—B' SECTION
11
10

FIG. 10

(a)



(b) A—A' SECTION



(c) B—B' SECTION

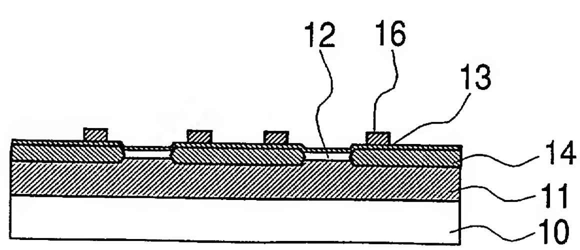


FIG. 11

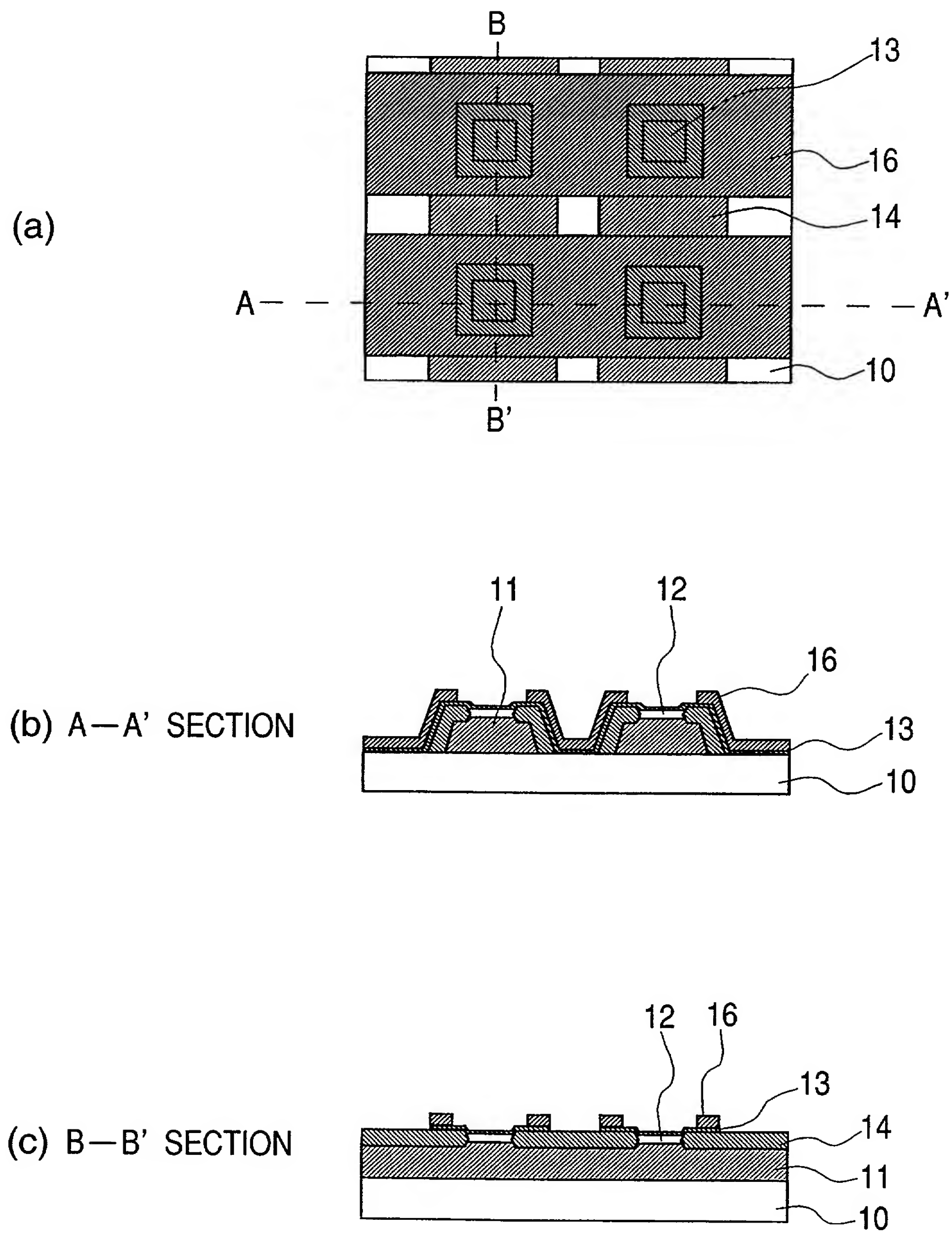

(a)
B
13
16
14
A
A'
10
B'
(b) A—A' SECTION
11
12
16
13
10
(c) B—B' SECTION
12
16
13
14
11
10

FIG. 12

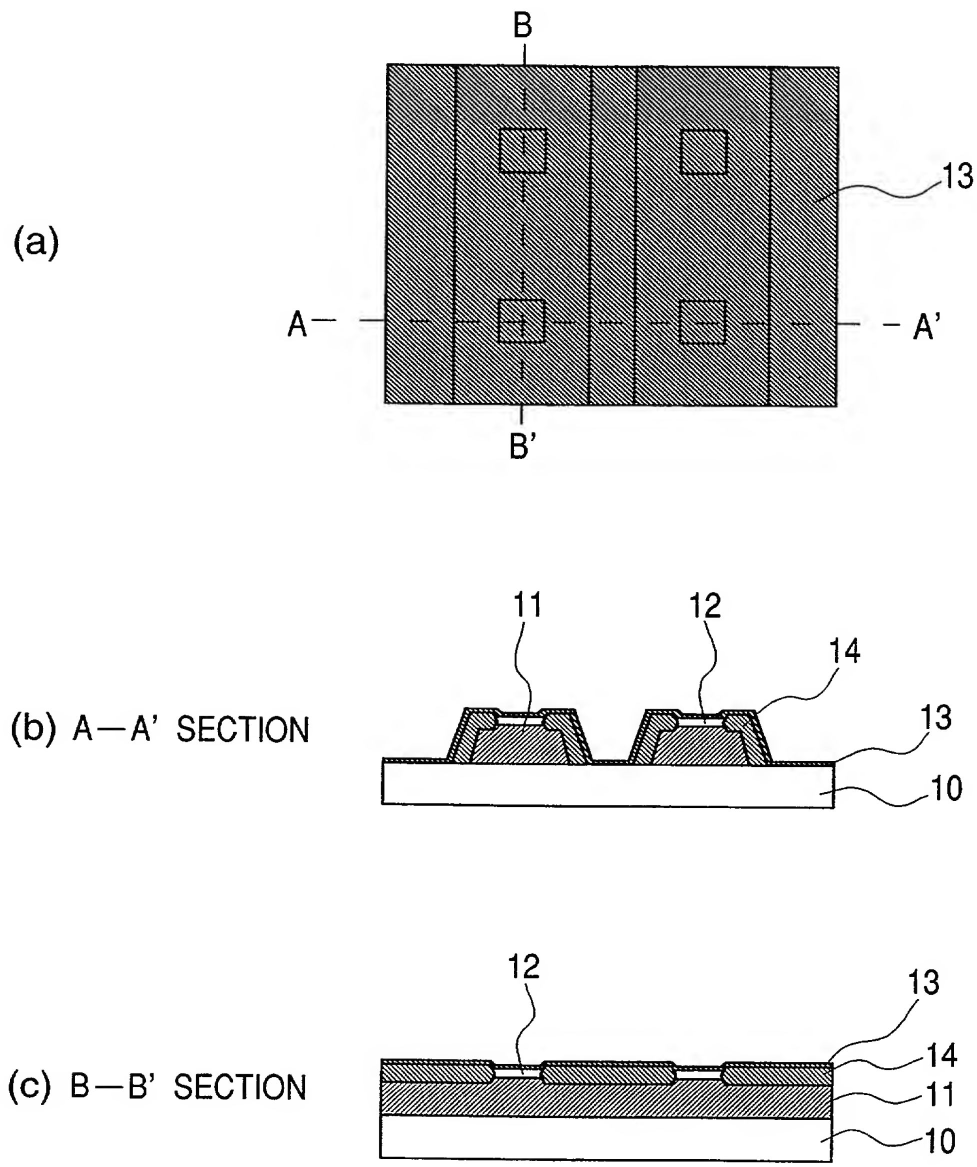
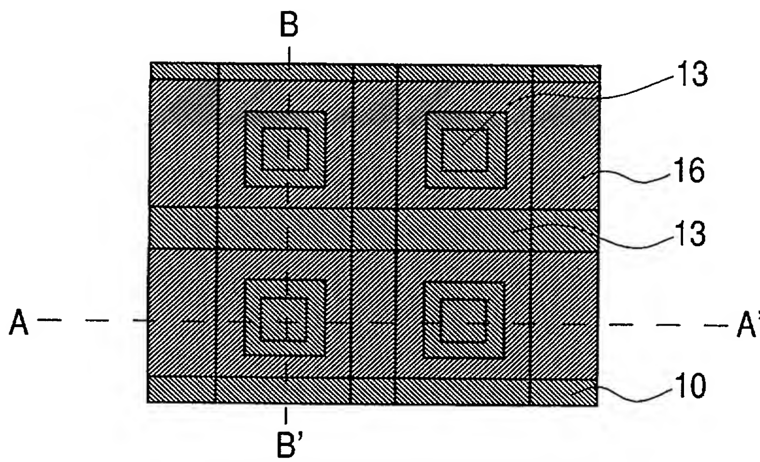
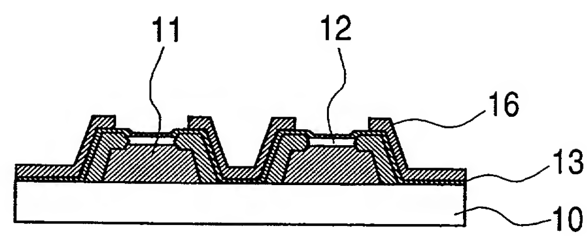


FIG. 13

(a)



(b) A—A' SECTION



(c) B—B' SECTION

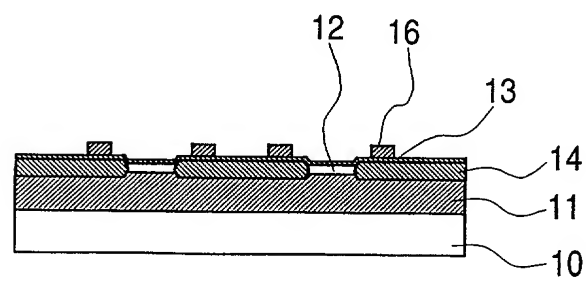
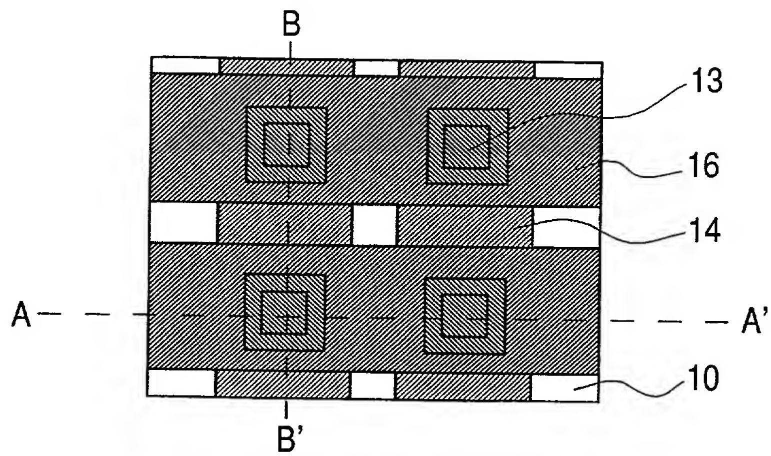
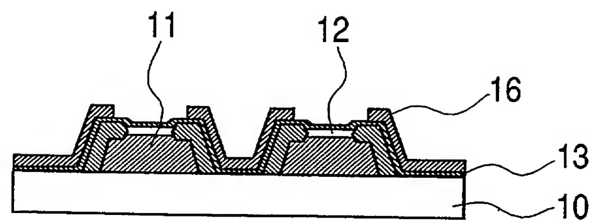


FIG. 14

(a)



(b) A—A' SECTION



(c) B—B' SECTION

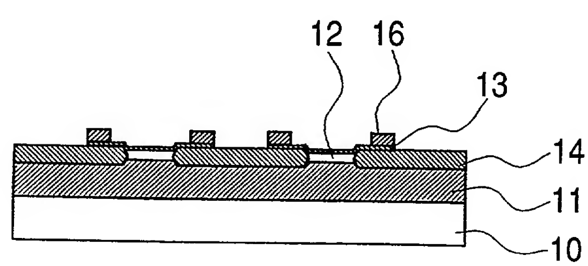


FIG. 15

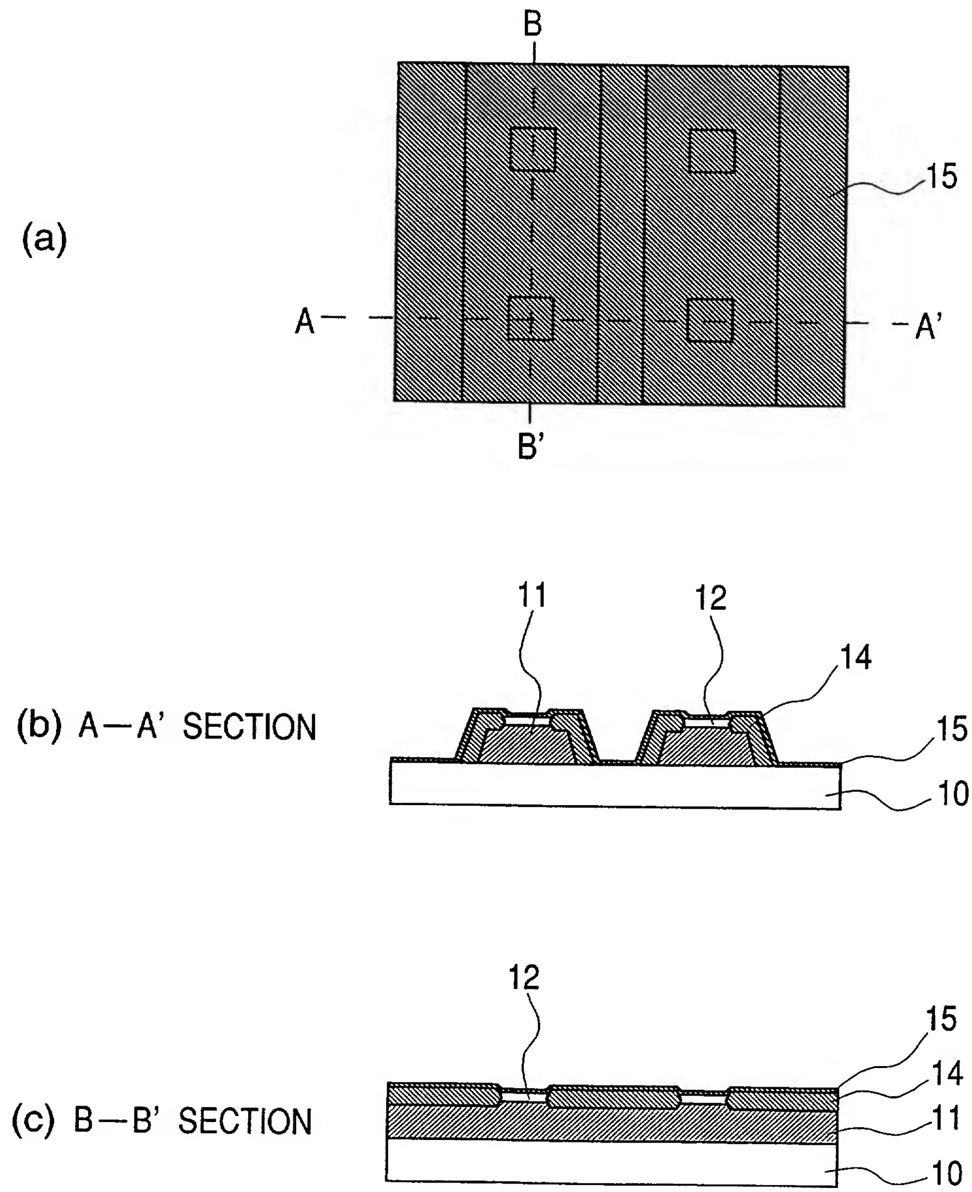
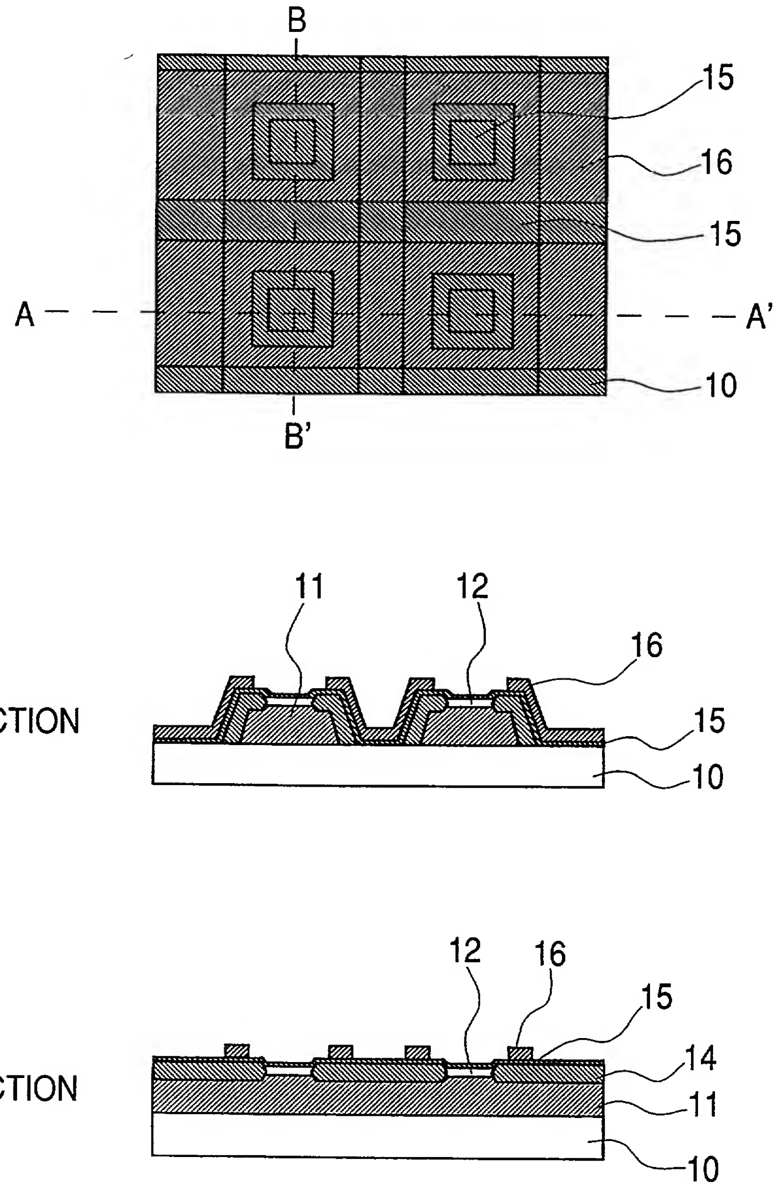


FIG. 16



(a)

(b) A—A' SECTION

(c) B—B' SECTION

FIG. 17

(a)

(b) A—A' SECTION

(c) B—B' SECTION

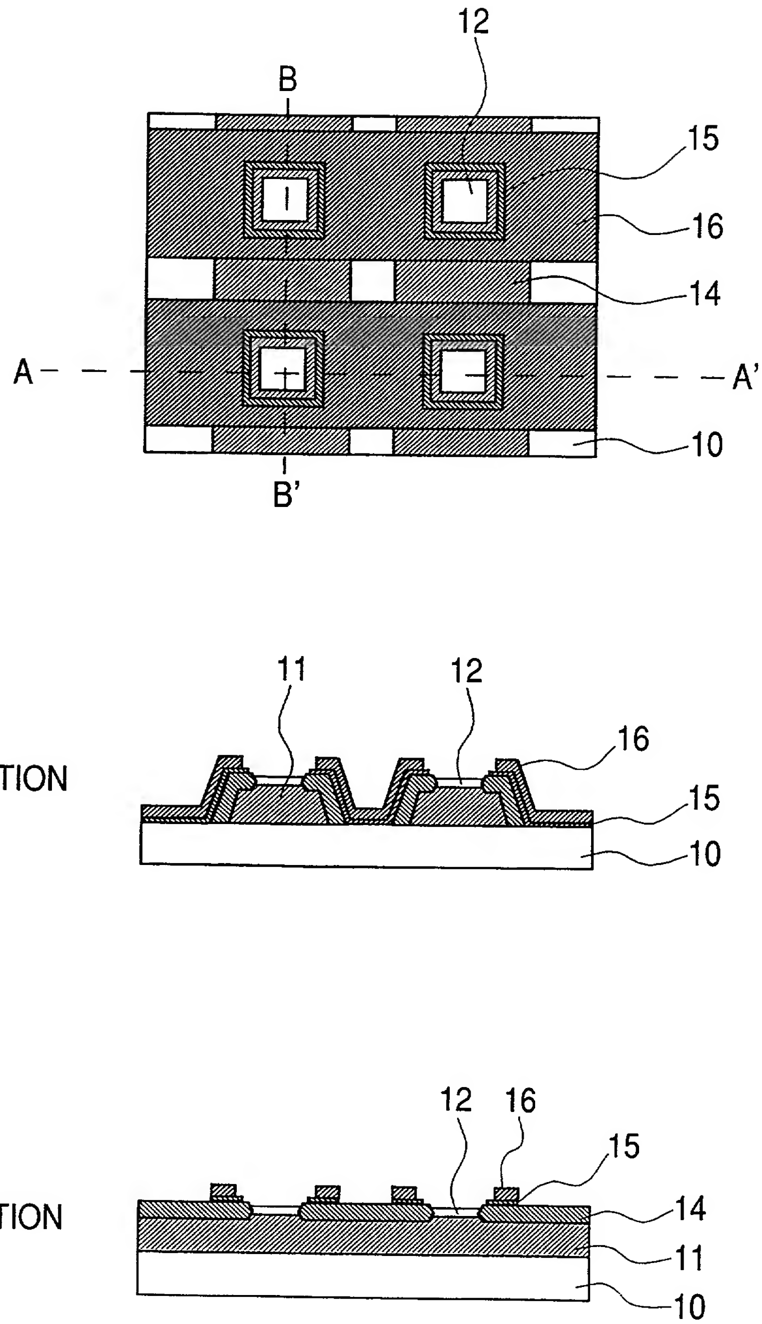
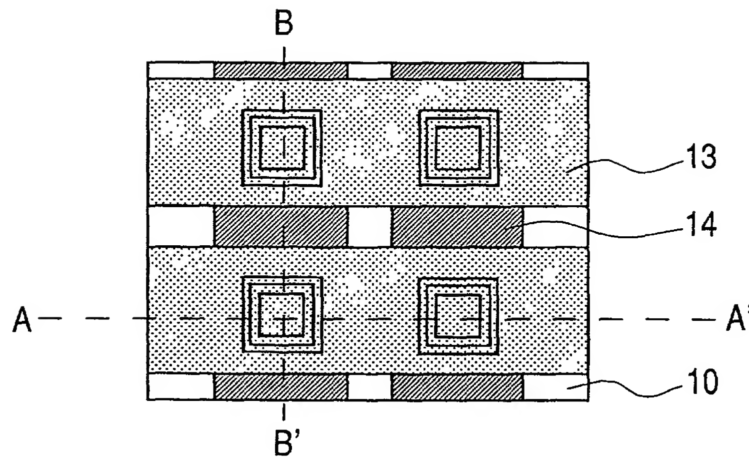
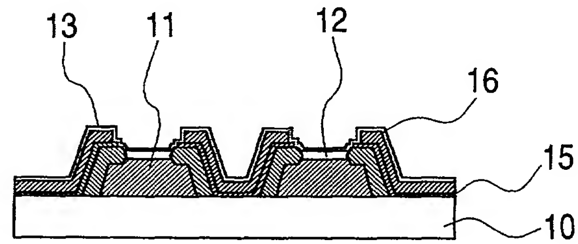


FIG. 18

(a)



(b) A—A' SECTION



(c) B—B' SECTION

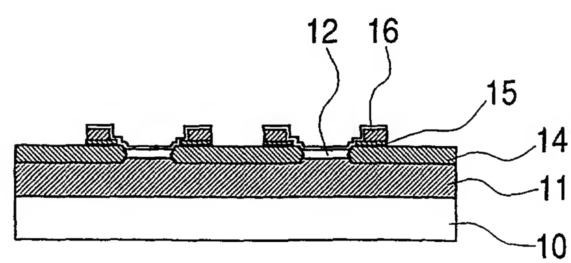


FIG. 19

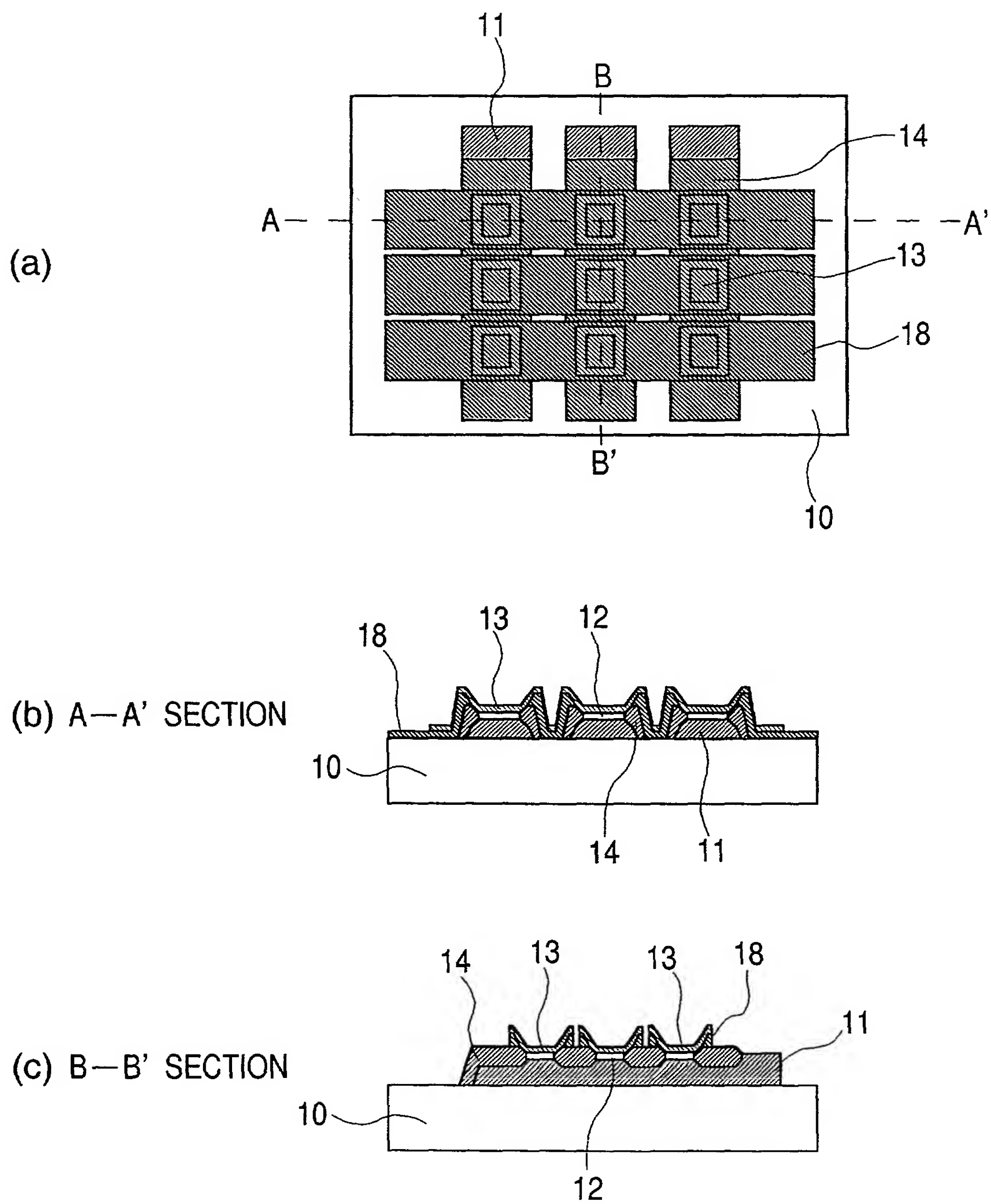

(a)
11
B
14
A
A'
13
18
B'
10
(b) A—A' SECTION
18
13
12
10
14
11
(c) B—B' SECTION
14
13
13
18
11
10
12

FIG. 20

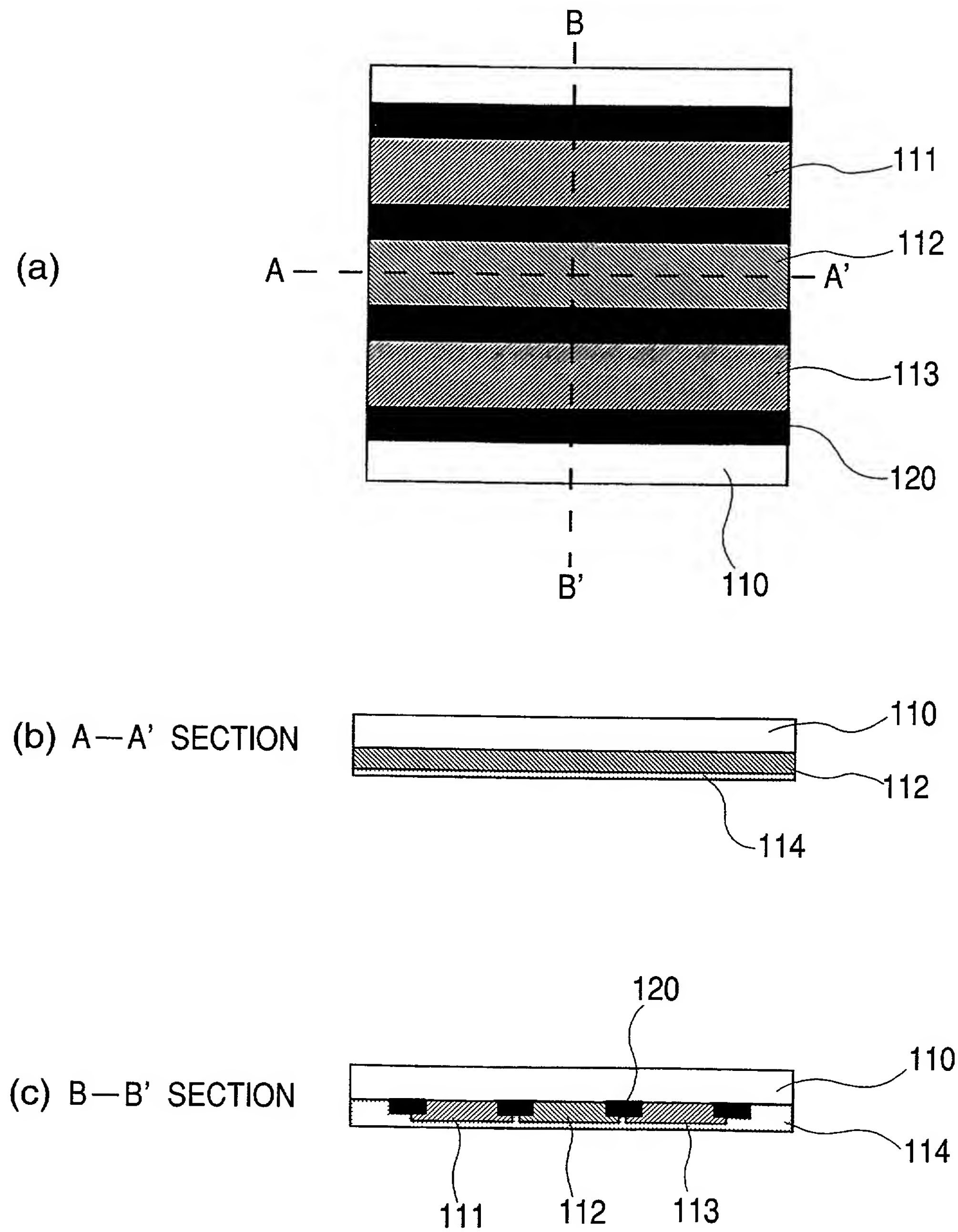

(a)
B
A
A'
111
112
113
120
B'
110
(b) A—A' SECTION
110
112
114
(c) B—B' SECTION
120
110
114
111
112
113

FIG. 21

(a) A—A' SECTION

(b) B—B' SECTION

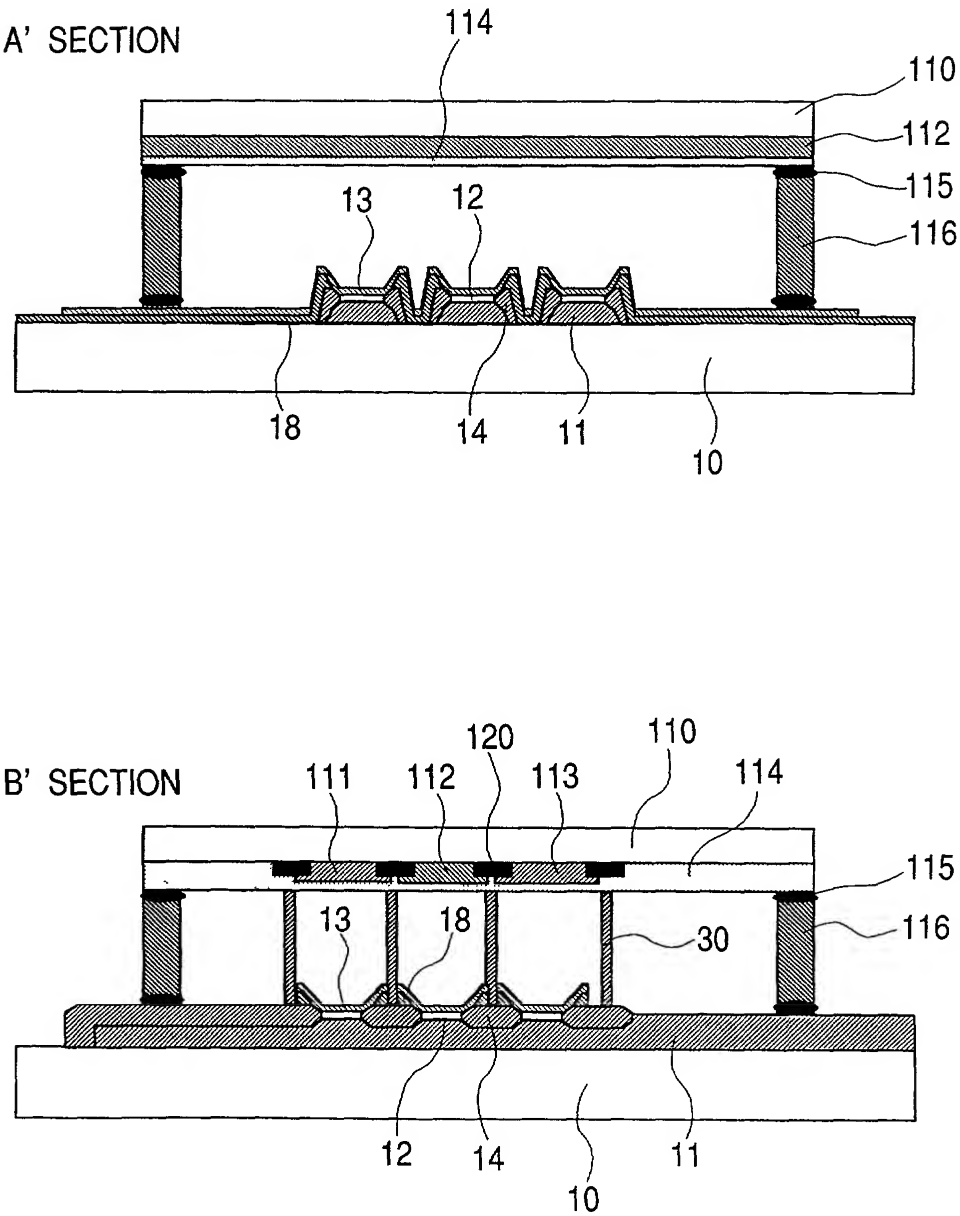


FIG. 22

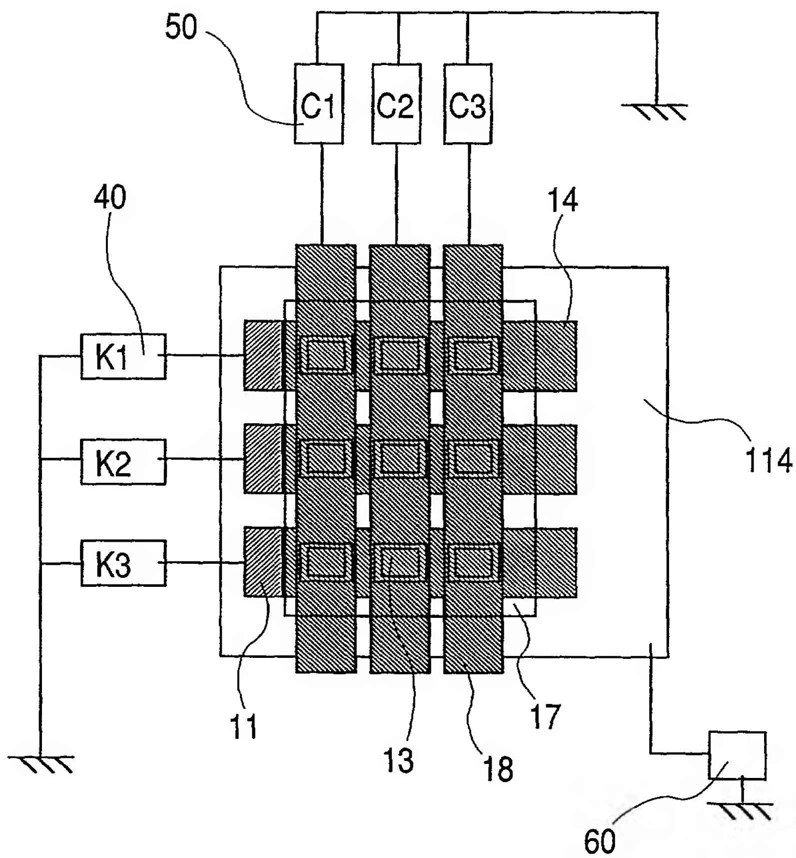


FIG. 23

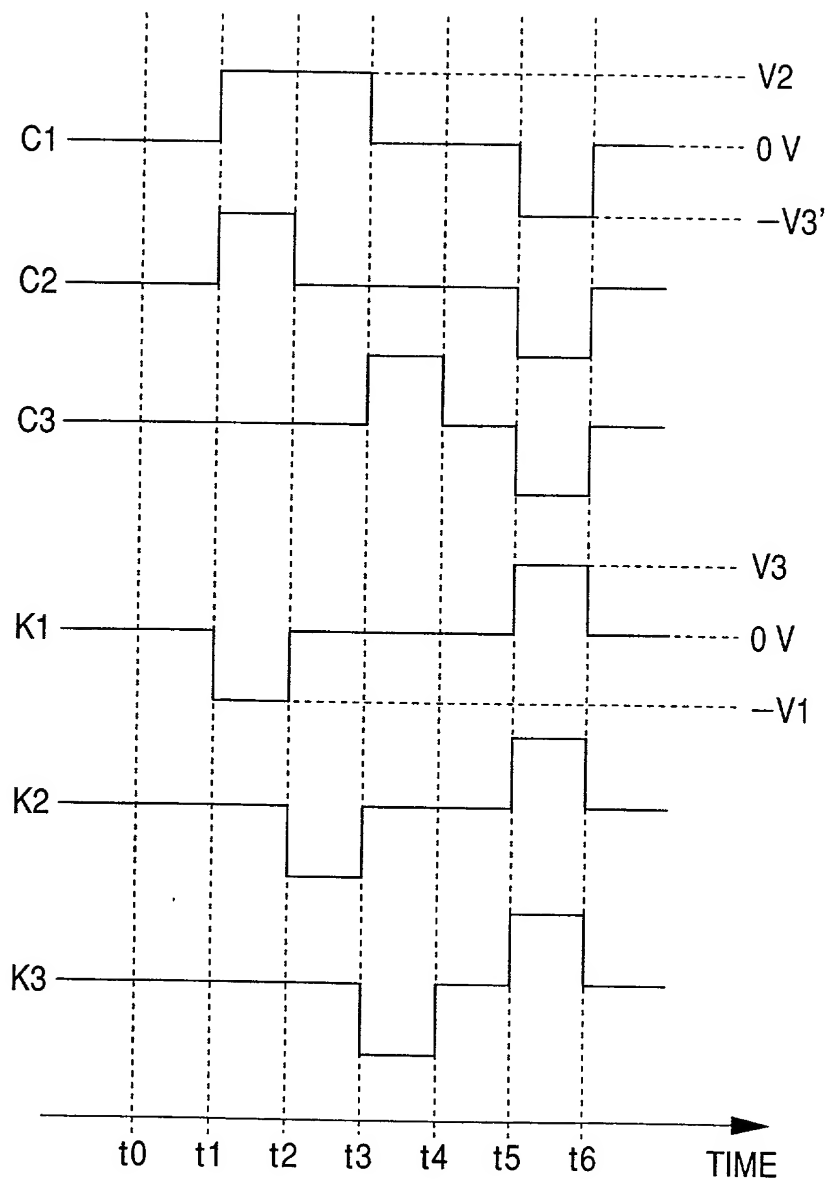
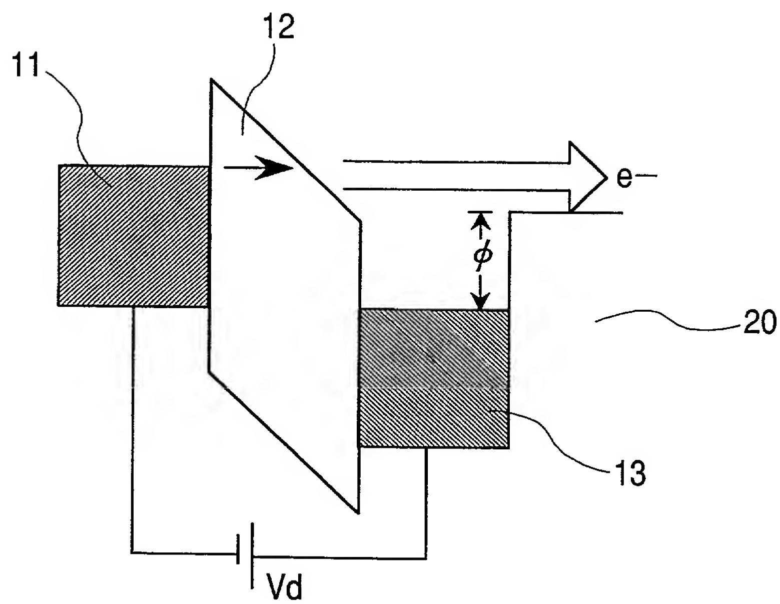


FIG. 24



PTO/SB/106(8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。	As a below named inventor, I hereby declare that:
私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。	My residence, post office address and citizenship are as stated next to my name.
下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。	I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
______	ELECTRON SOURCE, METHOD OF MANUFACTURE
______	THEREOF, AND DISPLAY DEVICE
上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、	The specification of which is attached hereto unless the following box is checked:
☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を__________とし、(該当する場合) __________に訂正されました。	☐ was filed on 30 / September / 1999 as United States Application Number or PCT International Application Number PCT / JP99 / 05401 and was amended on 13 / March /2000 (if applicable).
私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。	I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。	I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration
（日本語宣言書）

私は、米国法典第３５編１１９条 (a) - (d) 項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約３６５ (a) 項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
			☐
			☐

私は、第３５編米国法典１１９条 (e) 項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条 (c) に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*list name and registration number*)

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Shrinath Malur, Reg. No.34,663;
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唯一または第一発明者名	**Full name of sole or first inventor** 1-00 ~~Masakazu SAGAWA~~
発明者の署名 日付	**Inventor's signature** **Date** Masakazu Sagawa 3/6/2002
住所	**Residence** Inagi, Japan
国籍	**Citizenship** Japan JPX
私書箱	**Post Office Address** c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

（第二以降の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for second and subsequent joint inventors.)

第二共同発明者名 2-00	**Full name of second joint inventor, if any** Makoto OKAI
第二共同発明者の署名 日付	**Second inventor's signature** **Date** Makoto Okai 3/11/2002
住所	**Residence** Tokorozawa, Japan
国籍	**Citizenship** Japan JPX
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第三共同発明者名 3-00	**Full name of third joint inventor, if any** Mutsumi SUZUKI
第三共同発明者の署名 日付	**Third inventor's signature** **Date** Mitsumi Suzuki 3/6/2002
住所	**Residence** Kodaira, Japan
国籍	**Citizenship** Japan JPX
私書箱	**Post Office Address** c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第四共同発明者名 4-00	**Full name of fourth joint inventor, if any** Akitoshi ISHIZAKA
第四共同発明者の署名 日付	**Fourth inventor's signature** **Date** Akitoshi Ishizaka 3/6/2002
住所	**Residence** Chiba, Japan
国籍	**Citizenship** Japan JPX
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第五共同発明者名 5-00	**Full name of fifth joint inventor, if any** Toshiaki KUSUNOKI
第五共同発明者の署名 日付	**Fifth inventor's signature** **Date** Toshiaki Kusunoki 3/6/2002
住所	**Residence** Tokorozawa, Japan
国籍	**Citizenship** Japan JPX
私書箱	**Post Office Address** c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

（第六以降の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for sixth and subsequent joint inventors.)